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RESEARCH MEMORANDUM

TESTS OF A TRIANGULAR WING OF ASPECT RATIO 2 IN THE AMES 12-FOOT PRESSURE WIND TUNNEL. I – THE EFFECT OF REYNOLDS NUMBER AND MACH NUMBER ON THE AERODYNAMIC CHARACTERISTICS OF THE WING WITH FLAP UNDEFLECTED

By George G. Edwards and Jack D. Stephenson

Ames Aeronautical Laboratory
Moffett Field, Calif.

[redacted]

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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RESEARCH MEMORANDUM

TESTS OF A TRIANGULAR WING OF ASPECT RATIO 2 IN THE AMES 12-FOOT PRESSURE WIND TUNNEL. I – THE EFFECT OF REYNOLDS NUMBER AND MACH NUMBER ON THE AERODYNAMIC CHARACTERISTICS OF THE WING WITH FLAP UNDEFLECTED

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SUMMARY

A semispan model of a wing of triangular plan form and aspect ratio 2 has been tested in the 12-foot pressure tunnel to determine the aerodynamic characteristics of the wing as influenced by the independent effects of Reynolds number and Mach number up to Mach numbers approaching unity. The basic airfoil profile was an uncambered double wedge with maximum thickness of 5 percent of the chord at 20 percent of the chord. The tests included an investigation of the effects of minor modifications to the airfoil profile and the effect of addition of a fuselage.

Lift, drag, and pitching-moment data are presented through the angle-of-attack range at a Mach number of 0.18 for Reynolds numbers between 5,000,000 and 27,500,000. Similar data are presented at a Reynolds number of 5,300,000 for Mach numbers between 0.18 and 0.95. Some data for high Mach numbers are also included at a Reynolds number of 3,500,000.

The data presented in this report indicate no severe static longitudinal stability problems to be encountered up to a Mach number of 0.95. At a constant Reynolds number of 5,300,000, a Mach number change from 0.2 to 0.95 moved the aerodynamic center rearward a distance of about 5 percent of the mean aerodynamic chord, increased the lift-curve slope 20 percent, and increased the minimum drag 43 percent. The decrease in maximum lift-drag ratio due to increasing Mach number was smaller than might be expected due to a reduction in the rate of rise of drag with lift.

There was a change in the type of flow around this triangular wing at low speeds at a lift coefficient of about 0.7, which caused

a sudden forward shift in the center of pressure. Increasing Mach number increased the magnitude of this movement but also delayed its onset to higher lift coefficients.

Increasing Reynolds number from 5,000,000 to 27,500,000 at a constant Mach number of 0.18 caused a sizeable decrease in the drag but had little effect on the lift or the pitching moment.

The addition of a fuselage reduced the maximum lift-drag ratio and the lift-curve slope and resulted in a nominal increase in the drag. It also caused a slight forward shift of the aerodynamic center. The fuselage tended to reduce the severity of the center-of-pressure shift which was evident from the results of the tests of wing alone.

Minor modifications to the airfoil section had only a small effect on the aerodynamic properties of the wing.

INTRODUCTION

Of the wing plan forms suitable for flight at moderate supersonic speeds, triangular wings combine the structural efficiency of low aspect ratio and high taper with the aerodynamic efficiency of a highly swept-back leading edge. Theoretical calculations have shown that by judicious selection of wing profile and thickness ratio it is possible to attain lift-drag ratios at Mach numbers up to 1.5 which are sufficiently high to indicate that flight at this Mach number is practical with such a wing plan form (references 1, 2, and 3).

Consideration of the available low-speed data on low-aspect-ratio pointed wings has indicated that the landing and take-off problems, especially with respect to stability and control, may be less severe than those encountered with the more efficient supersonic plan forms combining high sweep with high aspect ratio.

As part of a general program of systematic research on supersonic airplane configurations at the Ames Aeronautical Laboratory, tests have been conducted in several different research facilities to determine the aerodynamic properties of triangular wings over a wide range of Mach numbers and Reynolds numbers. The results of tests at 1.53 Mach number of a triangular wing of aspect ratio 2.0 have shown reasonable agreement with theory and indicate that the supersonic performance of an airplane equipped with a triangular wing is sufficiently attractive to warrant a more thorough investigation.

The present series of tests in the 12-foot pressure wind tunnel is aimed at development of a triangular wing having satisfactory characteristics at Mach numbers approaching unity with reasonable assurance that the configuration will continue to be satisfactory at supersonic speeds. This report presents results of that portion of the investigation designed to establish the subsonic aerodynamic characteristics of the wing with undeflected flap as influenced by the independent effects of Reynolds number and Mach number. The effect of minor modifications to the wing profile and the effect of the addition of a fuselage are also included.

SYMBOLS

The following symbols are used in this report:

C_L lift coefficient $\left(\frac{\text{lift}}{qS}\right)$

C_D drag coefficient $\left(\frac{\text{drag}}{qS}\right)$

C_m pitching-moment coefficient about quarter-chord point of the wing mean aerodynamic chord $\left(\frac{\text{pitching moment}}{qSc'}\right)$

M Mach number $\left(\frac{V}{a}\right)$

R Reynolds number $\left(\frac{\rho Vc'}{\mu}\right)$

where

S wing area, square feet

c' wing mean aerodynamic chord, feet

c local chord, feet

q dynamic pressure, pounds per square foot $\left(\frac{1}{2}\rho V^2\right)$

ρ mass density of air, slugs per cubic foot

V airspeed, feet per second

μ viscosity of air, slugs per foot second

a speed of sound, feet per second

α angle of attack of wing chord line, degrees

TEST FACILITIES

This investigation was conducted in the Ames 12-foot pressure wind tunnel which is a closed-throat, variable-density wind tunnel having a nominal test section diameter of 12 feet. The circular test section has been modified by the addition of four equally spaced flat sections of 4-foot chord.

The density of the air in the tunnel is continuously variable from 1/6 to 6 times atmospheric density. Sufficient power is available to choke the wind tunnel at all tunnel pressures less than 0.40 of an atmosphere, allowing Reynolds numbers at choking up to 1,500,000 per foot. With a pressure of 6 atmospheres, a Reynolds number of 10,000,000 per foot is attainable at a Mach number of 0.25. This control of air density permits Reynolds number and Mach number to be varied independently without recourse to change in model size.

The turbulence level in the wind tunnel is exceptionally low, closely approaching that of free air. The moisture content of the air is maintained at all times below 0.0010 pounds of water per pound of air.

Force-test data are obtained with a six-component lever-type balance. The desired Mach number is maintained through the use of a specially calibrated Mach number indicator.

MODEL

The semispan model used in this investigation represented a triangular wing of aspect ratio 2.0. The original airfoil profile was an uncambered double wedge with a maximum thickness of 5 percent of the chord at 20 percent of the chord. The model, which was constructed of solid steel, had a 3-foot semispan and a 6-foot root chord as shown in figure 1. Two successive modifications were made to the airfoil section. The first of these consisted in rounding the ridge line, or line of maximum thickness, for a distance of 5 percent of the local chord ($r = 0.3222c$). Following tests of this configuration, the leading edge was rounded to a radius of 0.0025c. The majority of the tests were made with this modified profile. The wing conditions resulting from these progressive modifications, which involved slight changes in airfoil thickness ratio and plan form as shown in figure 1, are hereinafter referred to as wing condition A, B, or C.

The model was equipped with a full-span, constant-chord flap of which the area aft of the hinge line was 20 percent of the total wing area. The flap had a radius nose and the unsealed nose gap was 0.028 inch. The flap was attached to the airfoil by means of three hinges and restrained at the inboard end by a flap-angle indexing bracket and a strain-gage unit. For the present series of tests the flap was undeflected.

The wing model was also tested with a semifuselage mounted directly to the wing. The body dimensions and its location with respect to the wing are shown in figure 2. The body was fitted tightly to the wing with no fillet at the intersection.

The semispan model was mounted vertically in the wind tunnel, with the floor of the tunnel serving as a reflection plane. Photographs of the model installation are shown in figures 3 and 4. The rotating turntable upon which the model was mounted was connected directly to the force-measuring apparatus. Where the model extended beyond the turntable, the gap between the model and the tunnel floor was maintained between 0.010 inch and 0.150 inch. No attempt was made to remove the tunnel boundary layer which at the location of the model had a displacement thickness of 0.5 inch.

CORRECTIONS TO DATA

The data have been corrected for the effects of tunnel-wall interference, constriction due to the tunnel walls, model-support tare forces, and flap deformation.

Tunnel-Wall Interference

Corrections to the data due to tunnel-wall interference have been evaluated by the method of reference 4. The computations were slightly altered to take into account the effects of sweep. The introduction of a sweep factor decreased the correction over that for an equivalent unswept wing by 8 percent. The corrections applied were:

$$\Delta\alpha = 0.7222 \; C_L$$

$$\Delta C_D = 0.0107 \; C_L{}^2$$

No correction was applied to the pitching-moment data.

Blockage

The constriction effects due to the presence of the tunnel walls have been evaluated by the method of reference 5. This method has not been modified to allow for the effect of sweep. The magnitude of the correction applied to the Mach number and to the dynamic pressure is illustrated by the following table:

Corrected Mach number	Uncorrected Mach Number		q, corrected / q, uncorrected	
	Wing alone	Wing and body	Wing alone	Wing and body
0.95	0.933	0.912	1.017	1.052
.93	.918	.899	1.013	1.043
.90	.892	.877	1.009	1.034
.85	.845	.835	1.006	1.024
.80	.797	.790	1.004	1.018
.75	.748	.743	1.003	1.015
.70	.699	.695	———	1.012
.60	———	———	———	1.010
.50	———	———	———	1.008

Tares

Tare corrections for the air forces exerted on the exposed surface of the turntable have been applied to the drag data. The tare drag coefficient, obtained from turntable drag measurements at each test condition with the model removed from the tunnel, was found to decrease slightly with increasing Reynolds number. Over the range of test Reynolds numbers, the tare drag coefficient varied from 0.0028 to 0.0032 for the wing alone and from 0.0018 to 0.0022 for the wing with the fuselage. In the latter tares an allowance has been made for the reduction in the exposed area of the turntable with fuselage installed. No attempt was made to evaluate the possible interference effects between the model and the turntable or the effect of the gap between the surface of the turntable and the tunnel wall.

Induced Flap Deflection

A correction to the data was required as a result of angular deflection of the flap from its zero setting due to aerodynamic loads. This deviation in flap angle resulted from deflection of the flap hinge-moment strain-gage member and deformation of the flap-angle indexing bracket. Some angular distortion was also observed on the flap itself. Since the load distribution on the wing and flap was not known, a test was conducted in which the flap deflection was measured under actual conditions of aerodynamic loading. Three light beams were utilized, projected to mirrors attached to the flap at three spanwise positions. Reflected light cast from the mirrors to calibrated scales on the tunnel wall permitted accurate deformation data to be obtained while the tunnel was in operation. This deformation was correlated with the measured flap hinge moments. The effects of small flap deflections on the aerodynamic characteristics of the wing were then ascertained, and, on the basis of these tests, all lift, drag, and moment data were corrected to represent those of the wing with undeflected flap.

TESTS

Lift, drag, and pitching-moment data have been obtained over the angle-of-attack range with the flap set at zero deflection. At Reynolds numbers of approximately 3,500,000 and 5,300,000, data were obtained over a range of Mach numbers up to a maximum of 0.95. At a Mach number of 0.18, the range of Reynolds numbers was from 5,000,000 to 27,500,000.

The angle-of-attack range for the tests of the wing alone was from -10° to $+30^{\circ}$. At the higher Mach numbers, the angle range was reduced either by tunnel power limitations or by vibration of the flap. For tests with the wing-body combination, the angle-of-attack range was limited to $\pm 18^{\circ}$.

RESULTS AND DISCUSSION

Before the present series of tests was undertaken, considerable data were available on the effects of small profile modifications on the characteristics of a triangular wing at supersonic speeds and at speeds corresponding to landing and take-off. These data and theoretical considerations had shown that the most satisfactory profile would possess a finite leading-edge radius with the line of maximum thickness swept behind the Mach cone. On the assumption that rounding of the ridge line would permit slightly more favorable pressure recovery and a somewhat smaller thickness ratio with no increase in wing stress, it was decided, for the present series of tests, to concentrate on a modified double-wedge profile incorporating both a leading-edge radius and a rounded ridge line. This wing profile, condition C, was the only profile tested in the presence of a body and the data for this profile are presented first.

Effect of Reynolds Number

The aerodynamic characteristics of the wing alone are presented in figure 5 for Reynolds numbers from 5,000,000 to 27,500,000 at a Mach number of 0.18. In general, the effect of Reynolds number at this Mach number is small. Increasing the Reynolds number caused no change in wing lift but resulted in a slight rearward shift of the wing aerodynamic center and a decrease in the minimum drag.

These data indicate a rather abrupt change in the flow around the wing at a lift coefficient of 0.7. This change in the type of flow, which has previously been observed and discussed in reference 6, caused slight disturbances in the lift, and resulted in an abrupt shift in the center of pressure. Increasing the Reynolds number had no effect on the lift coefficient at which these disturbances occurred.

The variation of maximum lift-drag ratio and minimum drag with Reynolds number is shown in figure 6. The maximum value of L/D increased from 10.6 at a Reynolds number of 5,000,000 to 13.0 at a Reynolds number of 27,500,000, but the lift coefficient at which it occurred is indicated to be independent of Reynolds number. The minimum drag coefficient decreased from 0.0071 to 0.0057 due to increasing Reynolds number from 5,000,000 to 27,500,000.

The value of maximum lift-drag ratio is somewhat higher and the value of minimum drag considerably lower than those for a comparable Reynolds number reported in reference 7. The reason for this discrepancy is not known. The present method of establishing tares neglects any effects of interference between the model and the turntable. It is not immediately apparent how interference between these two components could be favorable. The effect of the tunnel boundary layer could, however, result in drag data which are too low. Considering the area of the model to be reduced by the tunnel-empty boundary-layer-displacement thickness results in only a 4-percent increase in the measured drag.

Effect of Mach Number

The effects of Mach number on the aerodynamic characteristics of the wing alone are presented in figures 7 through 10 for Mach numbers from 0.18 to 0.95 at a Reynolds number of 5,300,000. The lift curves of figure 7(a) show smooth and orderly Mach number effects up to a Mach number of 0.95. The pitching-moment curves of figure 7(b) show a progressive increase with Mach number of the lift coefficient at which the sudden shift in the center of pressure occurs. The resulting disturbance to the lift and the magnitude of the shift in center of pressure becomes more severe at the higher Mach numbers.

In figure 7(c), drag data for several Mach numbers are compared. These data show that, while the minimum drag increased with increasing Mach number, the drag due to lift becomes less as the Mach number is increased.

These Mach number effects are summarized in figure 8, which shows lift, drag, and pitching moment as functions of the Mach number. The effect of Mach number on the wing lift-curve slope and on the location of the aerodynamic center is shown in figure 9. The lift-curve slope increased about 0.01 per degree due to increasing the Mach number from 0.2 to 0.95. The reduced lift-curve slope measured at lift coefficients near zero is characteristic of wings of this low aspect ratio. There is a rearward shift of the aerodynamic center (at zero lift coefficient) from 39.5 percent to 44 percent of the mean aerodynamic chord as the Mach number is increased from 0.2 to 0.95.

As indicated in figure 10, the minimum drag coefficient remained constant at about 0.0070 up to 0.5 Mach number and then increased gradually with Mach number to 0.0102 at a Mach number of 0.95. The maximum lift-drag ratio, also shown in figure 10, decreased from a maximum of 11.2 at 0.5 Mach number to 9.6 at 0.95 Mach number. Above a Mach number of 0.5 the lift coefficient for maximum lift-drag ratio increased gradually with Mach number. At this point it should be noted that the trend of drag coefficient with Mach number may have been influenced by air leakage through the gap between the turntable and the tunnel. The early onset of minimum drag rise with increasing Mach number may be the result of a change in air-leakage effects with Mach number. Such leakage effects, if they were present, might also have caused a reduction in the rate of increase of lift-curve slope with increasing Mach number.

In discussing the reliability of these test data at Mach numbers above 0.90, consideration must be given to the magnitude of the constriction effects and the proximity of the test Mach number to the choking Mach number. The blockage or constriction correction, as has been pointed out, is not rigorous inasmuch as it is based wholly on model volume and wake and has not been corrected for the effects of sweep or the effects of model-tunnel configuration. The choking Mach number of the tunnel with wing alone has been computed to be 0.972. Actually, choking of the tunnel with the model installed occurred at a corrected Mach number of 0.975. This is no confirmation of the validity of the blockage correction, since the same correction is applied to both computations. However, a limited quantity of data has been obtained at a computed Mach number of 0.962 which agrees with the trends of the curves which are presented herein up to a Mach number of 0.95.

If the Mach numbers indicated on these figures are slightly higher than the actual values due to the constriction corrections being too large, there is still every evidence that abrupt force breaks do not occur with this wing plan form and that the Mach number effects indicated in this report would not change markedly at a true Mach number of 0.95.

Effect of Reynolds Number at High Mach Number

At the highest Mach number for which data are presented ($M = 0.95$) it was possible to vary the Reynolds number from 3,500,000 to 5,300,000. Data obtained at these two extremes of Reynolds numbers at Mach numbers ranging from 0.6 to 0.95 indicate no discernable effect of Reynolds number (fig. 11). There is reason to believe that Reynolds number effects may be appreciable at high Mach numbers and Reynolds numbers in the region of 1,000,000. Further tests are desirable to extend the range of Reynolds numbers at high Mach numbers to values lower than 3,500,000.

Effect of Body

The effects of Reynolds number and Mach number on the characteristics of the wing-body combination are shown in figures 12, 13, and 14. Comparison of the data with those for the wing alone indicates an increase in the minimum drag coefficient due to addition of the fuselage of about 0.0044 for all Mach numbers up to 0.9. At 0.93 Mach number the increase was 0.0049 and at 0.95, it was 0.0055. Comparisons of the lift, drag, and pitching-moment data for the wing alone and the wing-body combination are shown in figure 15 for a Mach number of 0.18 and a Reynolds number of 15,000,000.

Figure 16 presents the variation of lift-curve slope and aerodynamic center with Mach number for the wing with a fuselage and for the wing alone. As shown, addition of the fuselage reduced the lift-curve slope an amount depending on the Mach number and the lift coefficient. It also resulted in a forward shift in the location of the aerodynamic center (about 1.5 percent M.A.C.), although the change in static margin due to increasing Mach number remained the same as for the wing alone.

The variation of lift-drag ratio with lift coefficient at several Mach numbers is presented in figure 17. Comparison of the curves for the wing alone and the wing-body combination shows a reduction in maximum lift-drag ratio due to addition of the body of about 2.1 throughout the range of Mach numbers.

As previously mentioned in the discussion of the wing-alone results, the variation of minimum drag and lift-curve slope with Mach number may have been influenced by air-leakage effects.

The Effect of Wing-Profile Modification

The effects of minor variations to the airfoil section of the triangular wing are shown in figures 6, 10, and 18 through 20. The effect of replacing the finite nose radius with a sharp leading edge (condition B) was to slightly decrease the minimum drag and cause a somewhat more rapid increase of drag with lift (fig. 19). There was no significant effect of nose radius on the maximum lift-drag ratio (figs. 6 and 10). At a Mach number of 0.18, the sharp leading edge had little effect on the lift coefficient at which the discontinuity in the moment curves occurred, but it caused a more abrupt and larger shift in center of pressure. At Mach numbers above 0.3 however, the sharp leading edge not only increased the lift coefficient for the moment shift but also tended to reduce the severity of the discontinuity.

Replacing the rounded ridge lines with sharp ridge lines, combined with sharp leading edge (condition A), had no significant effect on any of the wing characteristics.

CONCLUDING REMARKS

The results of wind-tunnel tests of a semispan model of a triangular wing of aspect ratio 2 have been presented. The tests were conducted to determine the separate effects of Mach number and Reynolds number on the aerodynamic characteristics of the wing alone and the wing in combination with a fuselage. Also included were tests to determine the effect of rounding the leading edge and the ridge lines of the basic uncambered double-wedge profile.

Data obtained for a range of Mach numbers from 0.2 to 0.95 at a constant Reynolds number of 5,300,000 indicated the following:

1. There was a smooth, orderly increase in static-longitudinal stability with increasing Mach number, the aerodynamic center moving aft a distance of 5 percent of the mean aerodynamic chord.

2. The sudden forward shift of the center of pressure, which occurs at a lift coefficient of about 0.7 at low speed, was increased in magnitude and delayed to higher lift coefficients at the higher Mach numbers.

3. At a Mach number of 0.95, the lift-curve slope had increased 20 percent and the minimum drag 43 percent over the low-speed value.

The effects of Reynolds number as determined from these tests may be summarized as follows:

1. In a range of Reynolds numbers from 5,000,000 to 27,500,000 at a constant Mach number of 0.18, an increase in Reynolds number decreased the minimum drag and increased the lift-drag ratio, but had little effect on the lift or the pitching moment.

2. In the range of Reynolds numbers from 3,500,000 to 5,300,000 at high subsonic Mach numbers, no scale effects were indicated.

The addition of a fuselage reduced the maximum lift-drag ratio and the lift-curve slope and resulted in a nominal increase in the drag. It also caused a slight forward shift of the aerodynamic center. The fuselage tended to reduce the severity of the center-of-pressure shift which was evident from the results of the tests of wing alone.

Minor modifications to the airfoil section had only a small effect on the aerodynamic properties of the wing.

Ames Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Moffett Field, Calif.

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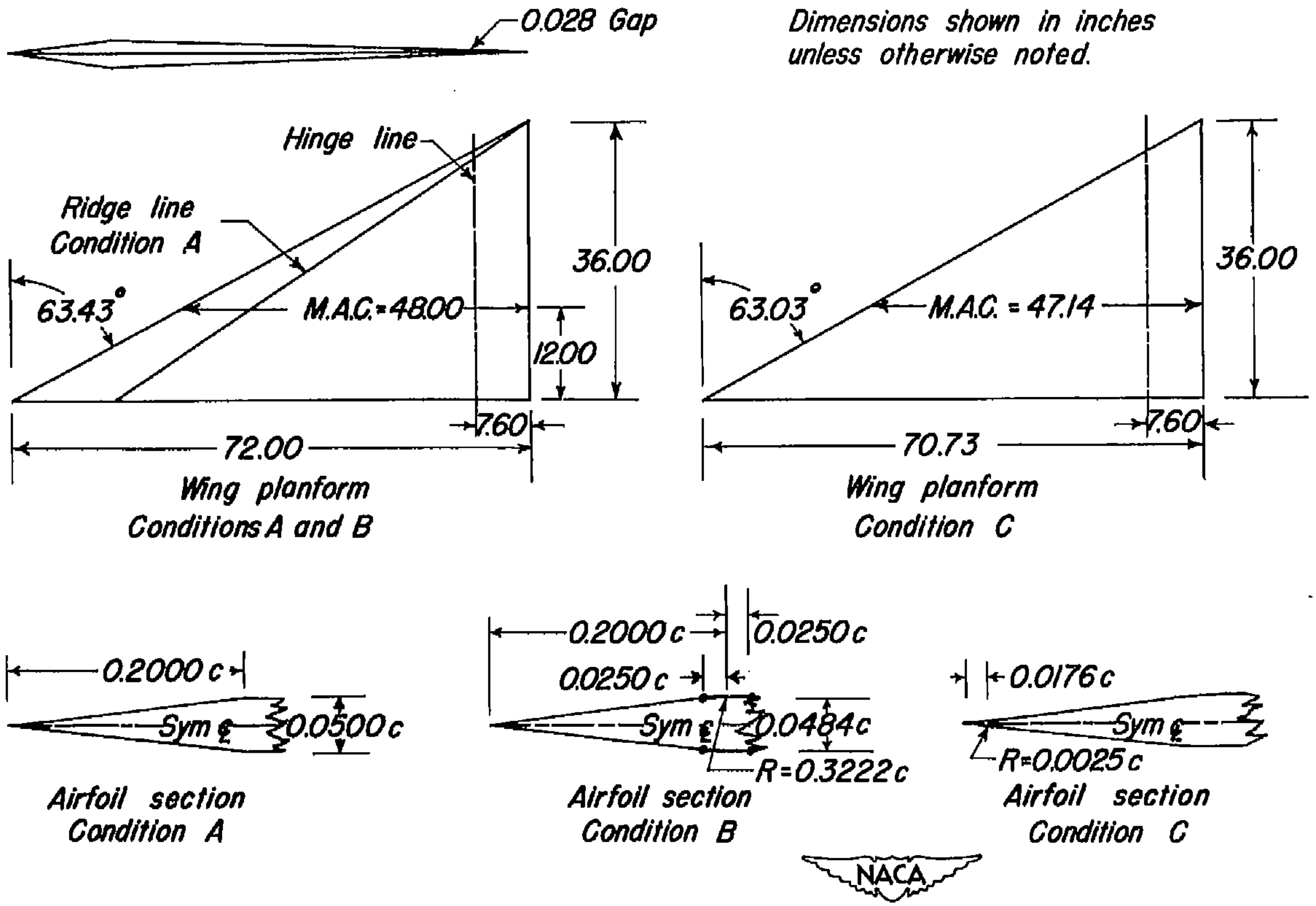
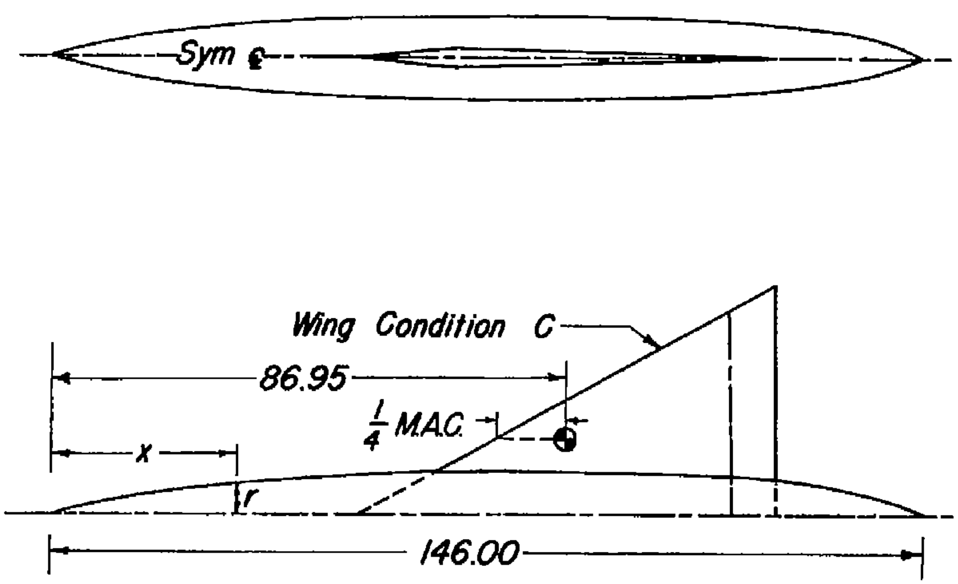


Figure 1.- Semispan model of a triangular wing of aspect ratio 2 tested in the 12-foot pressure wind tunnel.

Note: Dimensions shown in inches



Body ordinates (Percent length)			
x	r	x	r
0	0	61.60	4.398
3.42	0.904	68.50	4.252
6.85	1.480	75.30	3.992
10.27	1.958	83.20	3.575
13.70	2.370	84.95	3.445
20.55	3.034	86.30	3.310
27.40	3.553	89.00	2.938
34.23	3.939	91.80	2.460
41.10	4.211	94.50	1.835
47.92	4.375	97.30	1.034
54.80	4.430	99.30	0.293
55.50	4.439	100.00	0

Figure 2.- The wing-body combination tested in the 12-foot pressure wind tunnel.

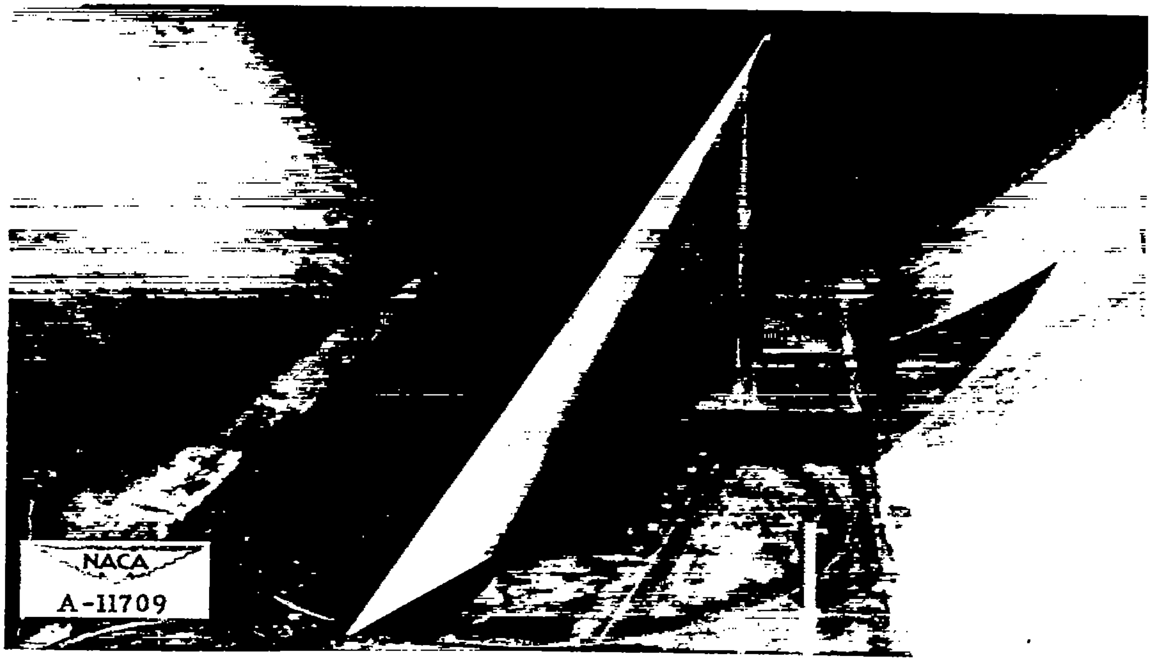


Figure 3.— Semispan wing, condition C, mounted in the 12-foot pressure wind tunnel.

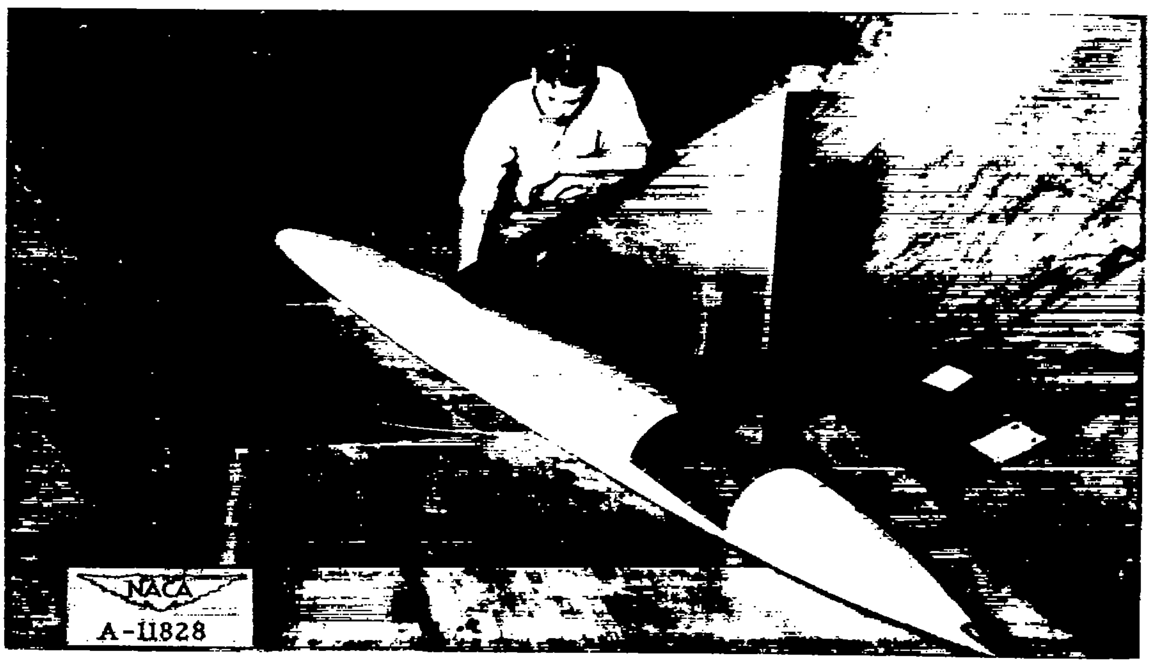
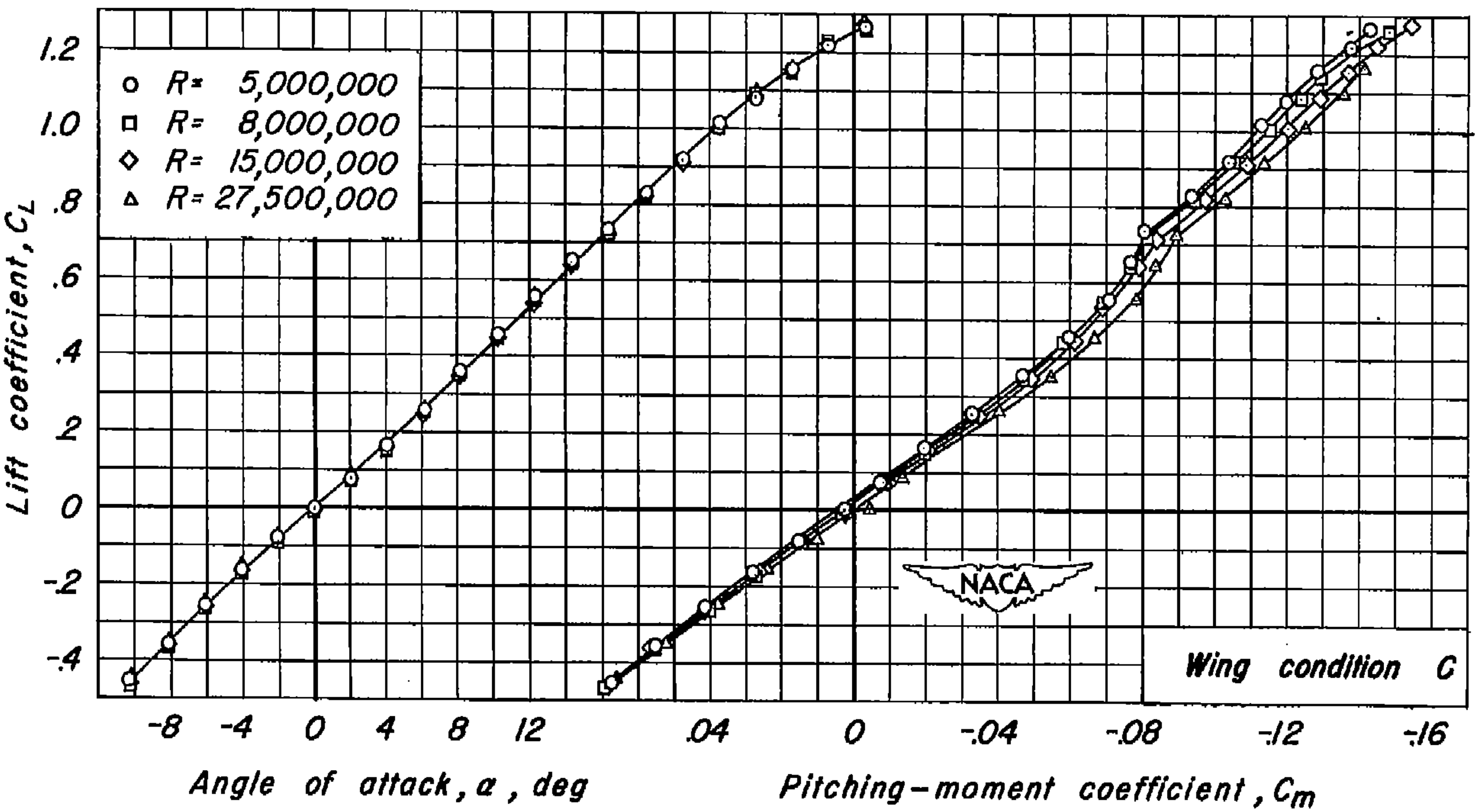
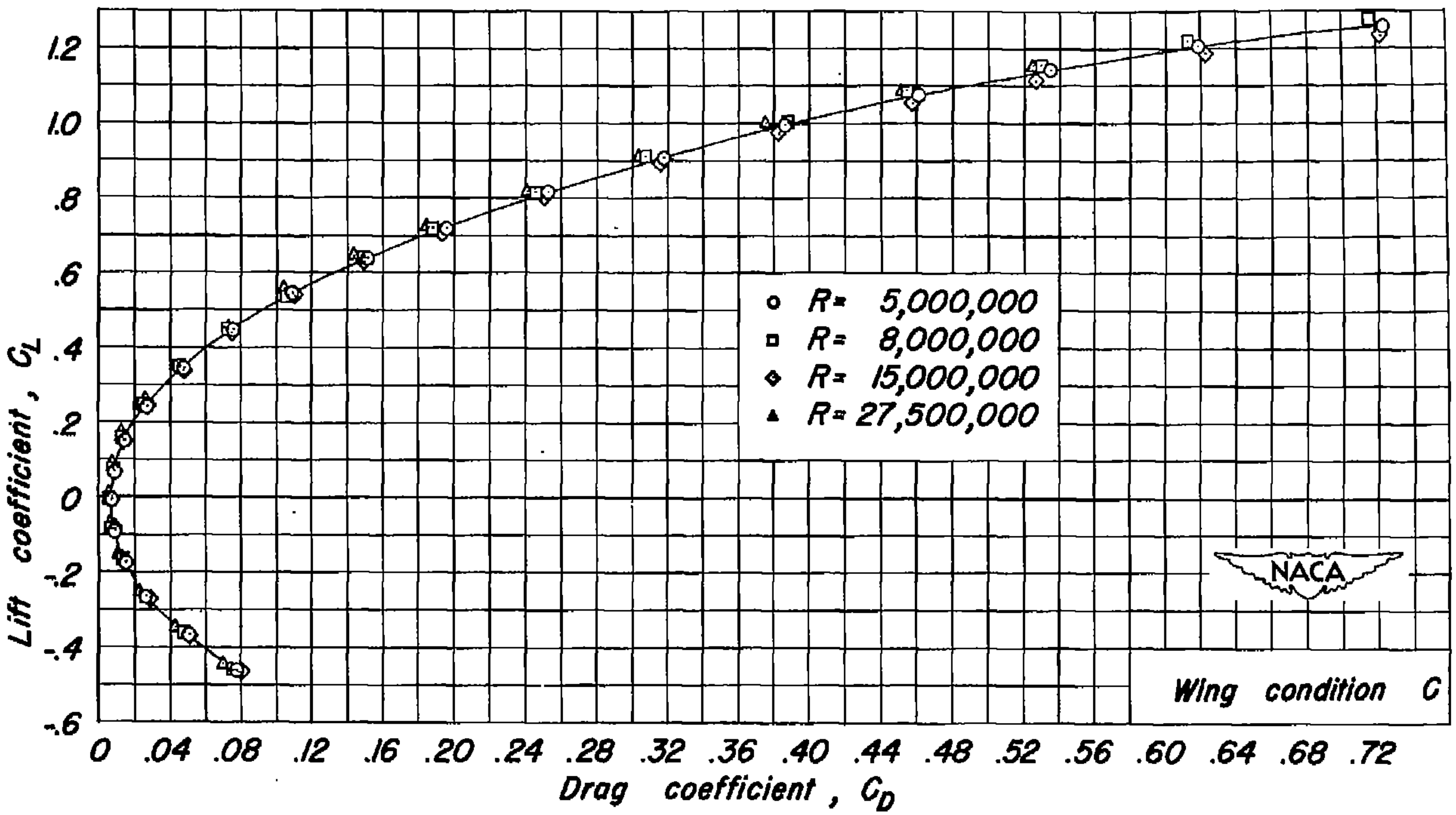


Figure 4.— Semispan wing-body combination mounted in the 12-foot pressure wind tunnel.



(a) C_L vs α, C_L vs C_m

Figure 5.- The effect of Reynolds number on the aerodynamic characteristics of a triangular wing at a Mach number of 0.18.



(b) C_L vs C_D

Figure 5.- Concluded.

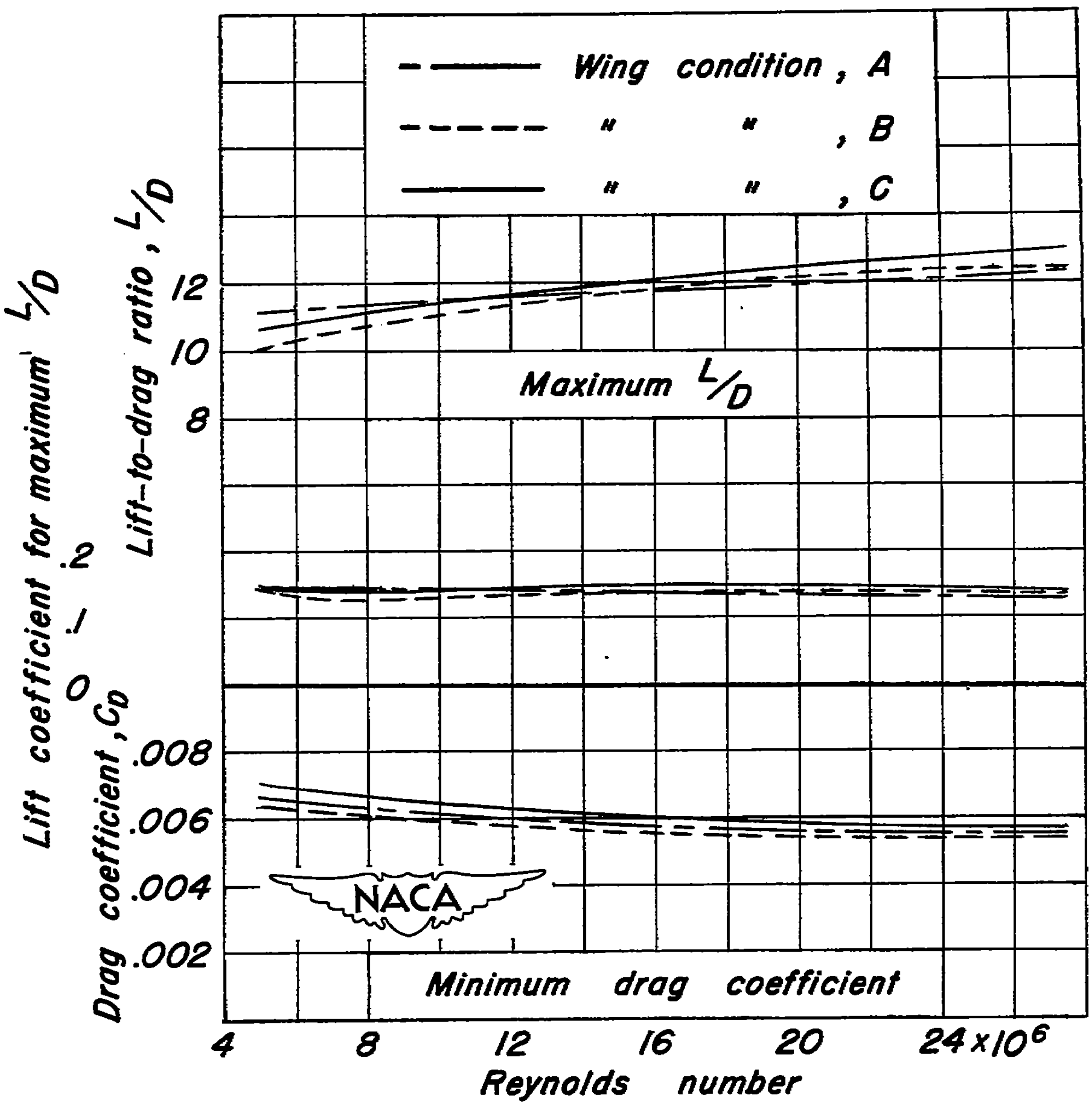
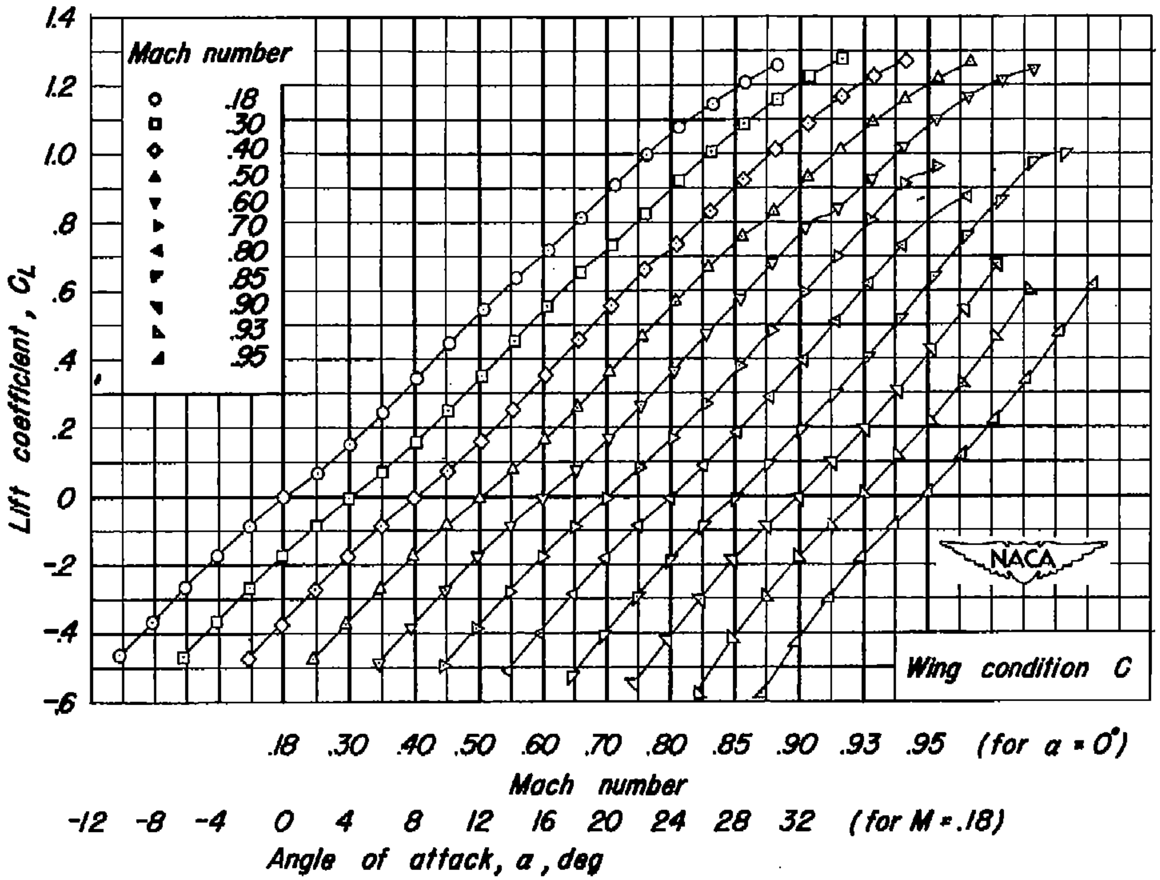
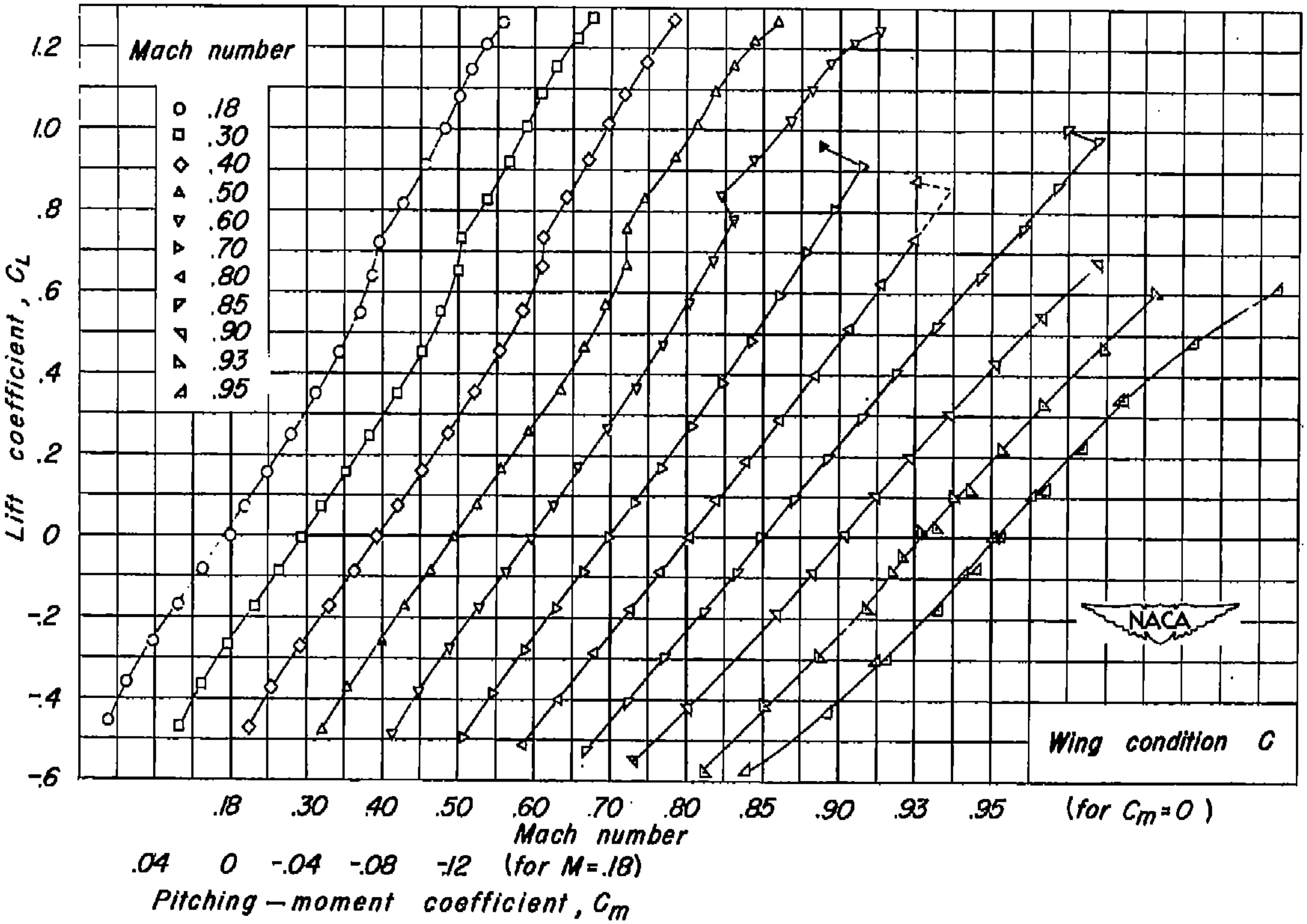


Figure 6.- The effect of Reynolds number on the maximum lift-to-drag ratio and minimum drag of a triangular wing at a Mach number of 0.18 for three wing-profile conditions.



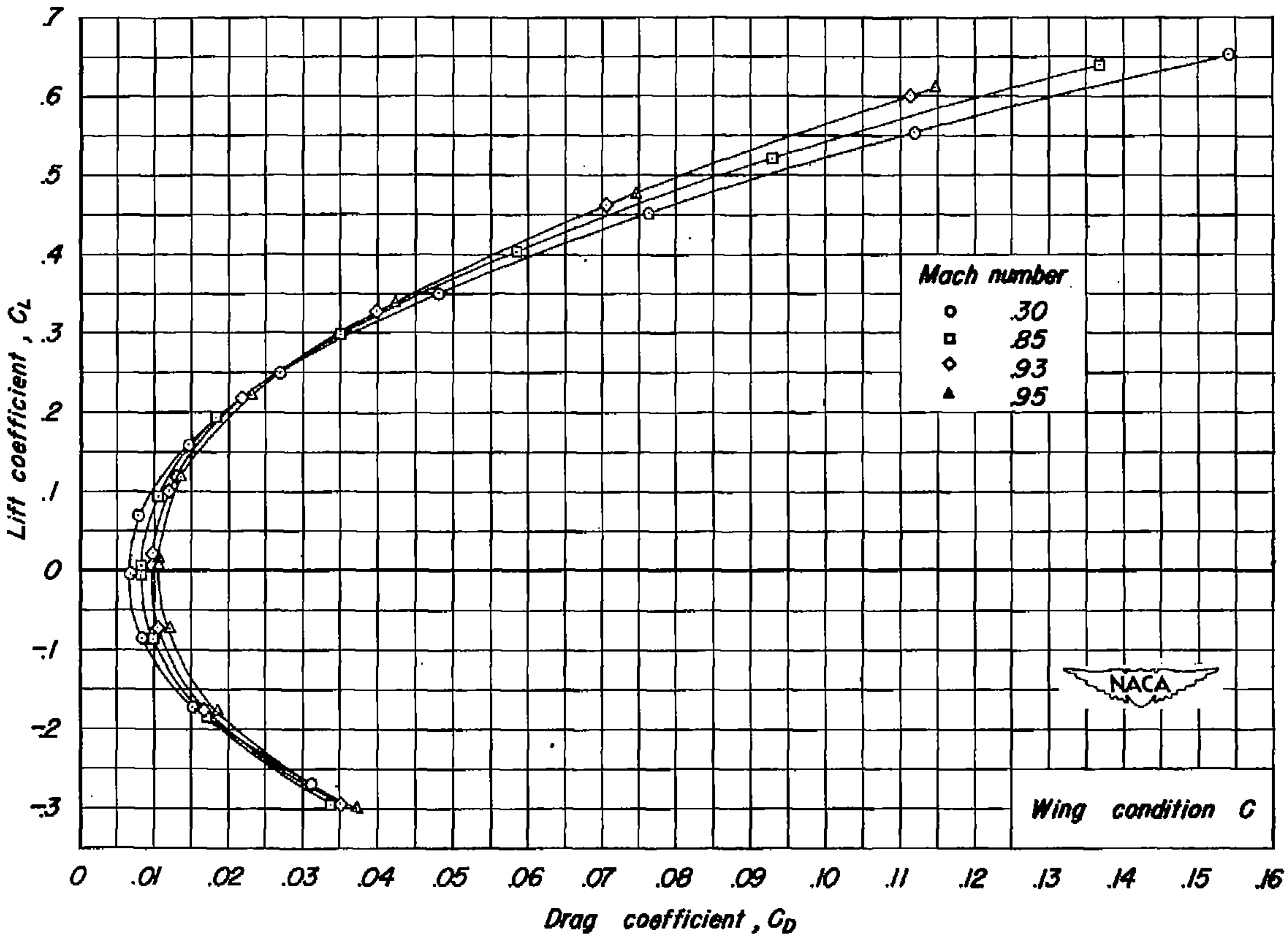
(a) C_L vs α

Figure 7.–The effect of Mach number on the aerodynamic characteristics of a triangular wing at a Reynolds number of 5,300,000.



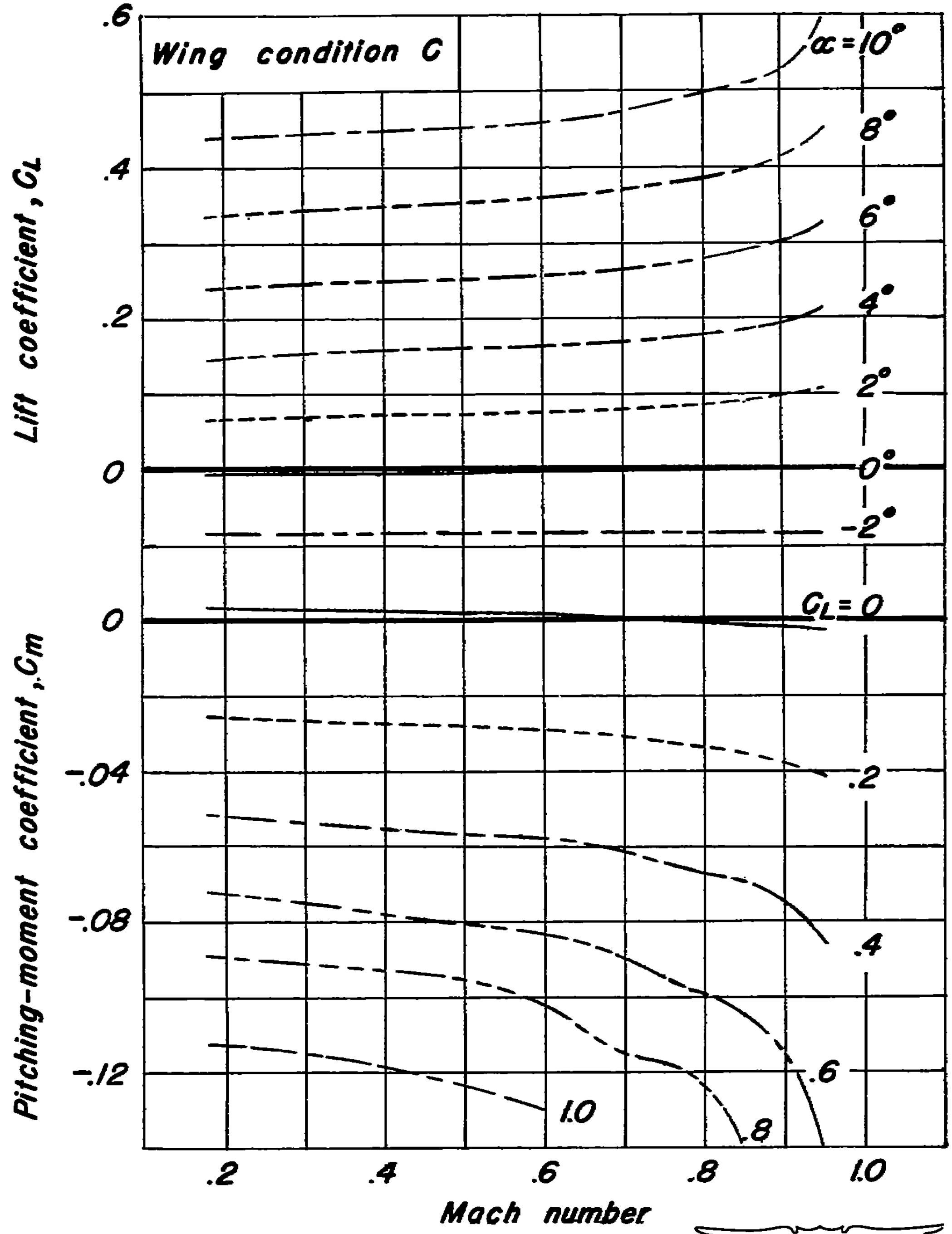
(b) C_L vs C_m

Figure 7.- Continued.



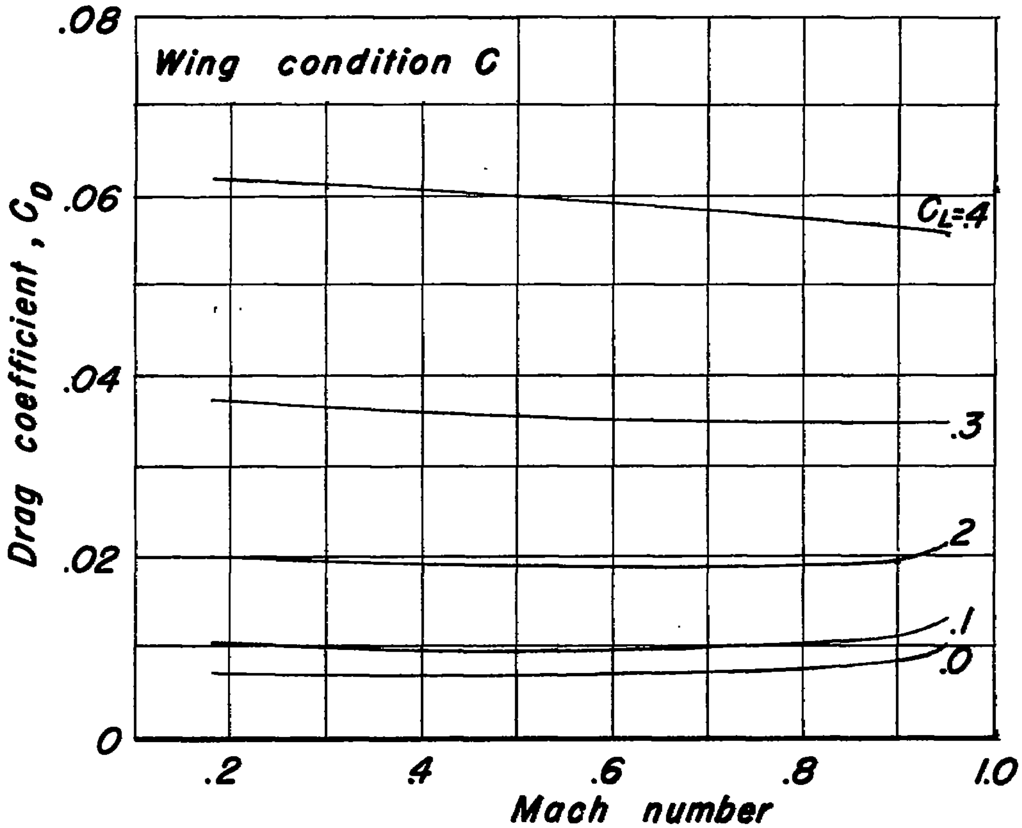
(c) C_L vs C_D

Figure 7.– Concluded.



(a) C_L vs M, C_m vs M

Figure 8.- The effect of Mach number on the lift, drag, and pitching-moment coefficients of a triangular wing at a Reynolds number of 5,300,000.



(b) C_D vs M

Figure 8.– Concluded.

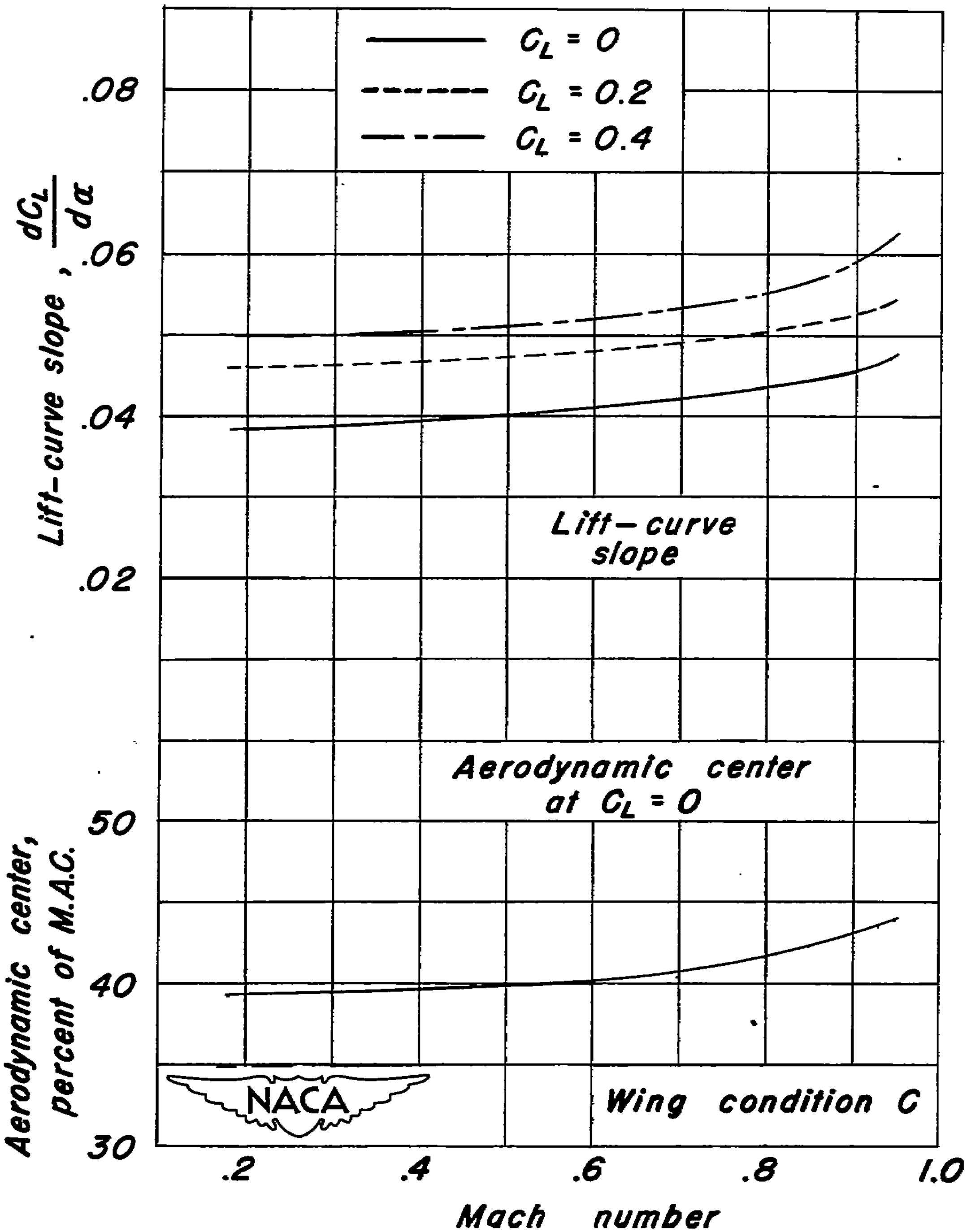


Figure 9.- The effect of Mach number on lift-curve slope and aerodynamic center of a triangular wing at a Reynolds number of 5,300,000.

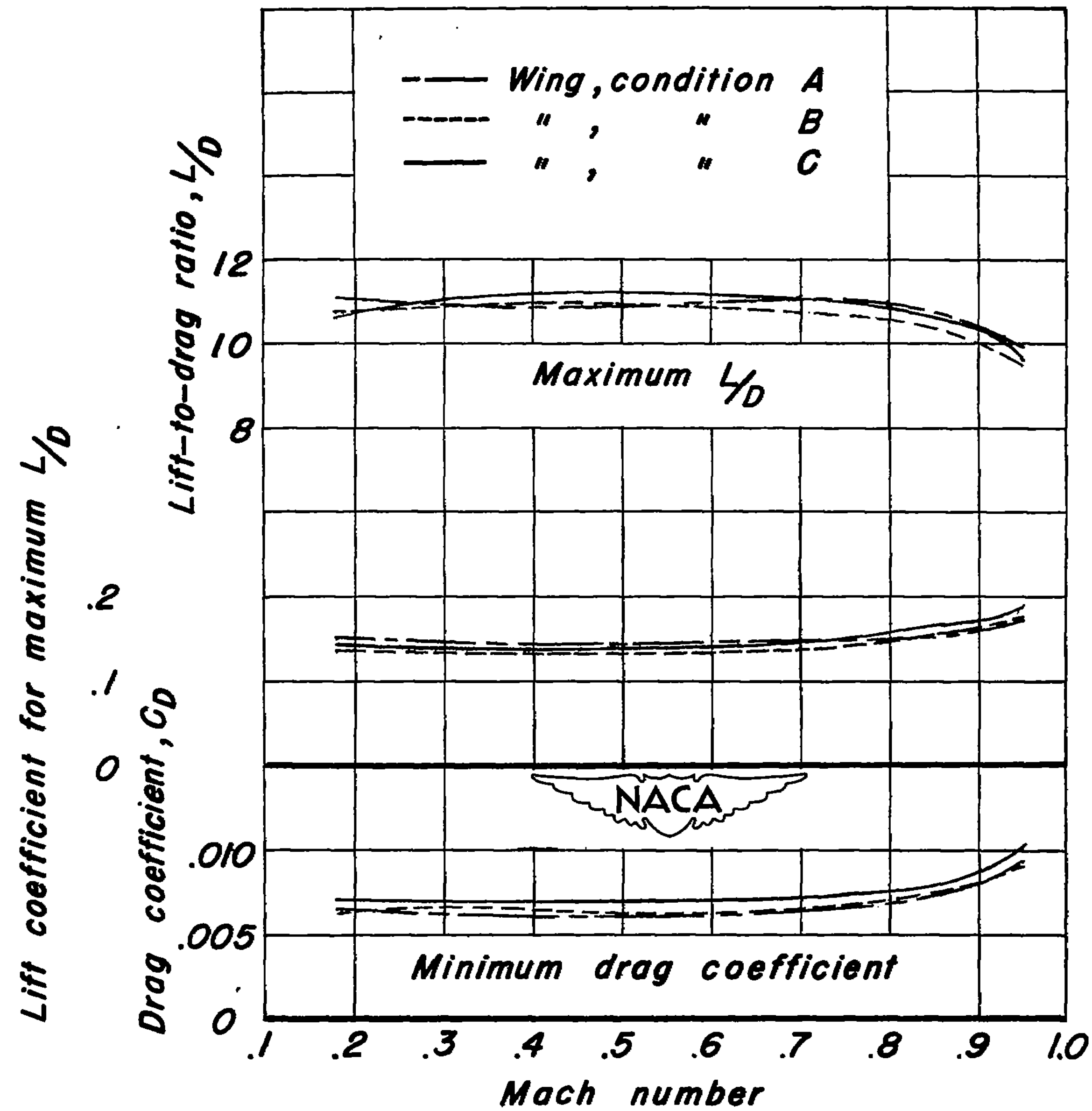


Figure 10.– The effect of Mach number on maximum lift-to-drag ratio and minimum drag of a triangular wing at a Reynolds number of 5,300,000 for three wing-profile conditions.

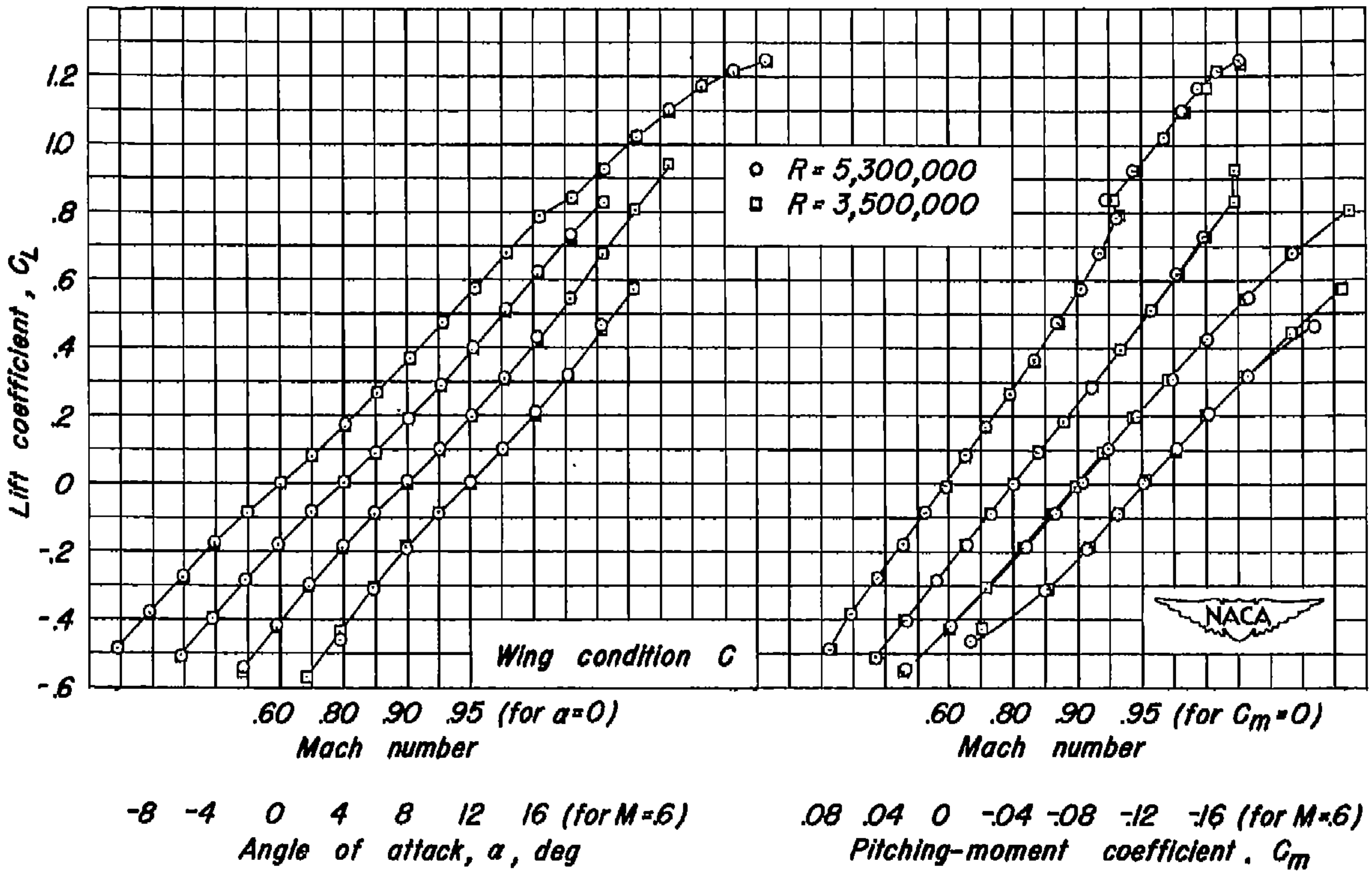


Figure 11.- The effect of Reynolds number on the aerodynamic characteristics of a triangular wing at several high subsonic Mach numbers.

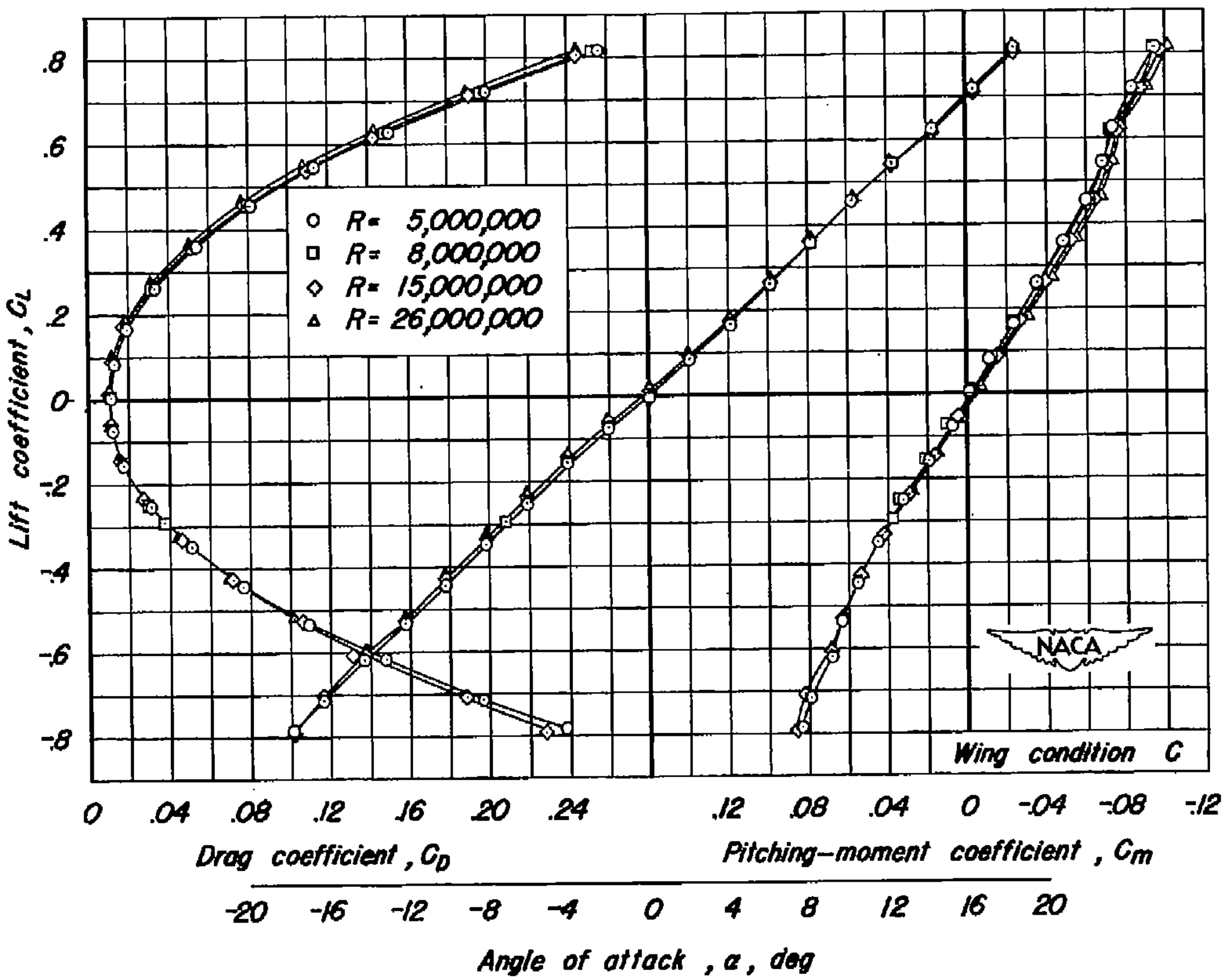
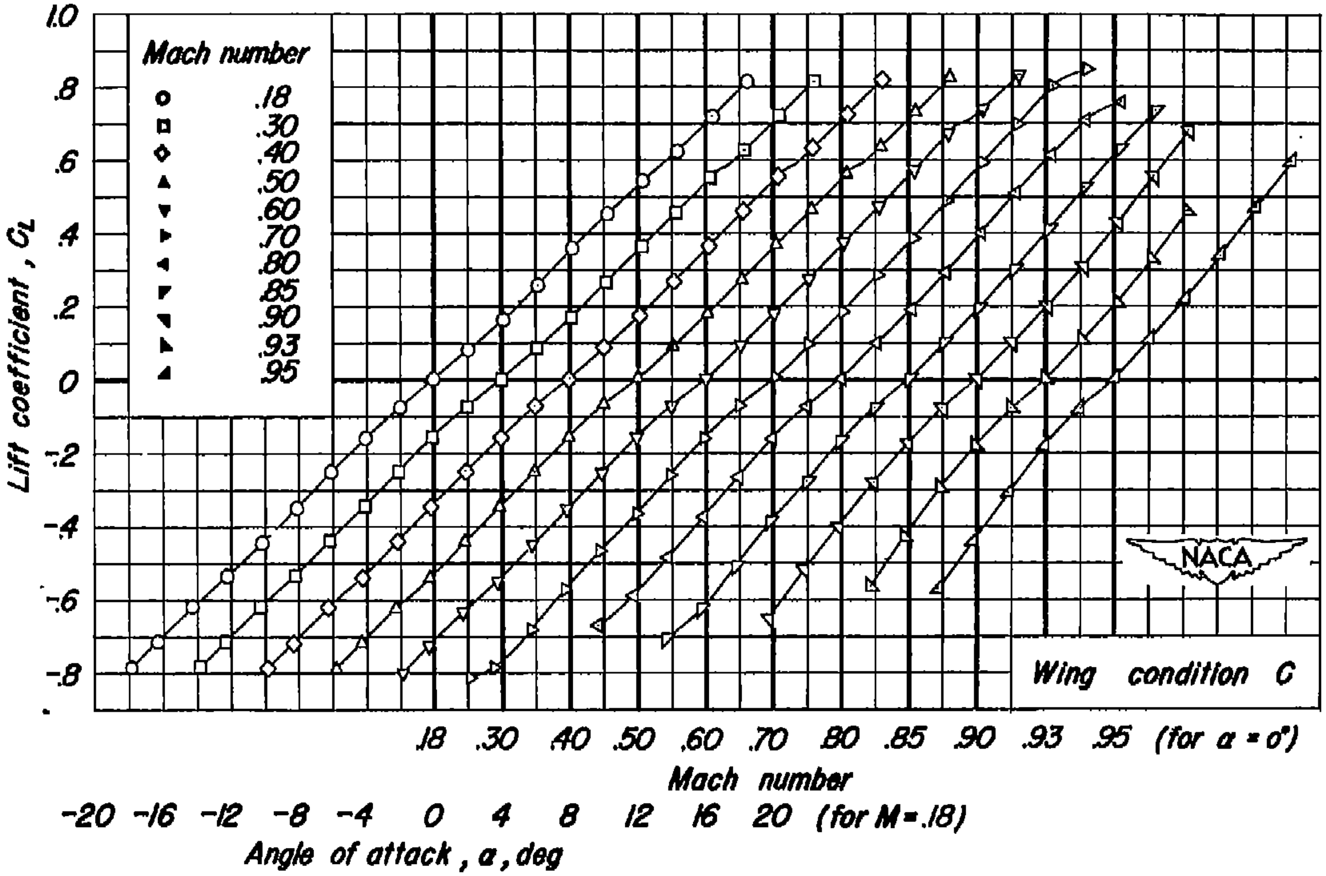
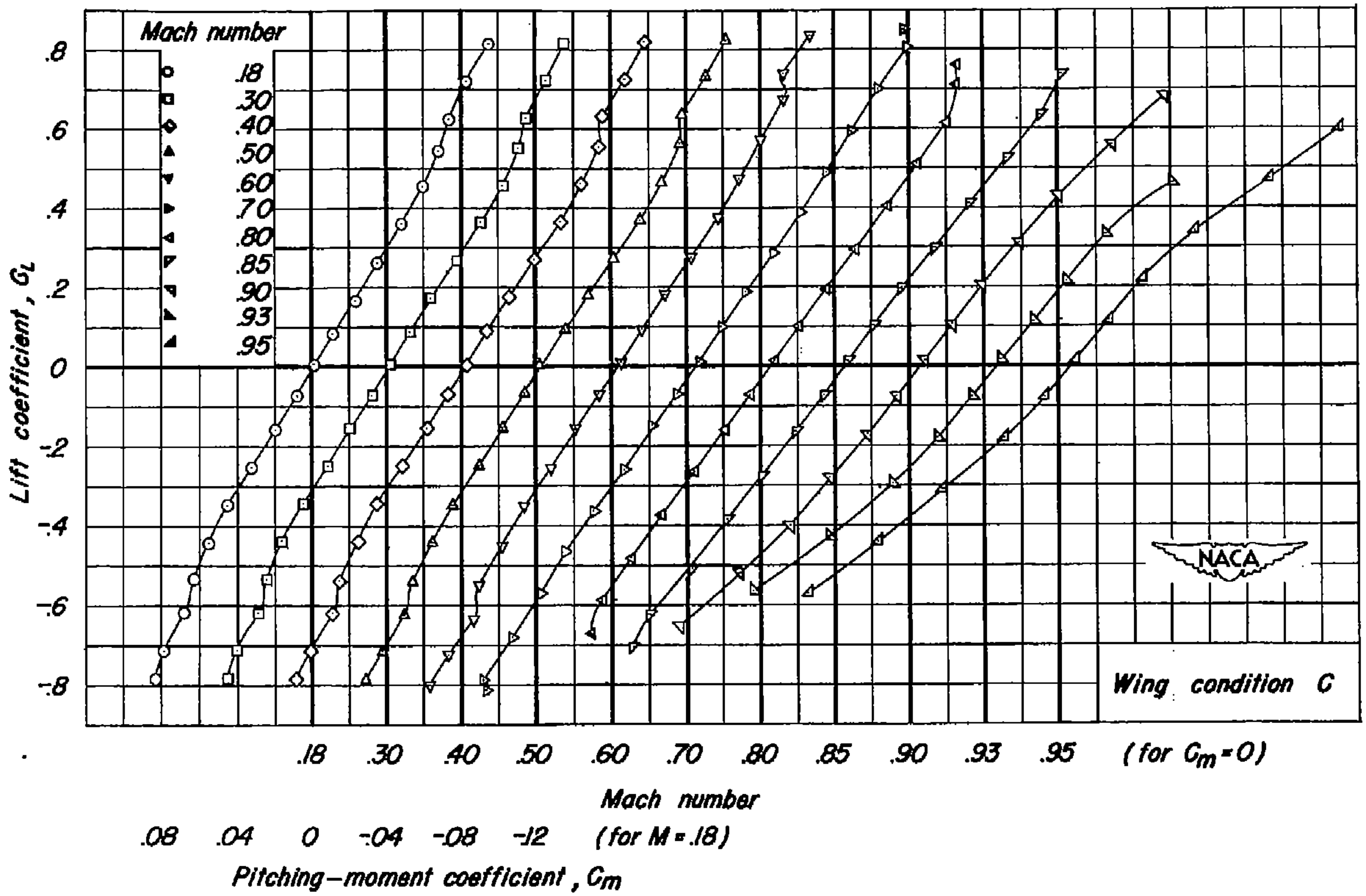


Figure 12.–The effect of Reynolds number on the aerodynamic characteristics of a triangular wing with fuselage at a Mach number of 0.18.



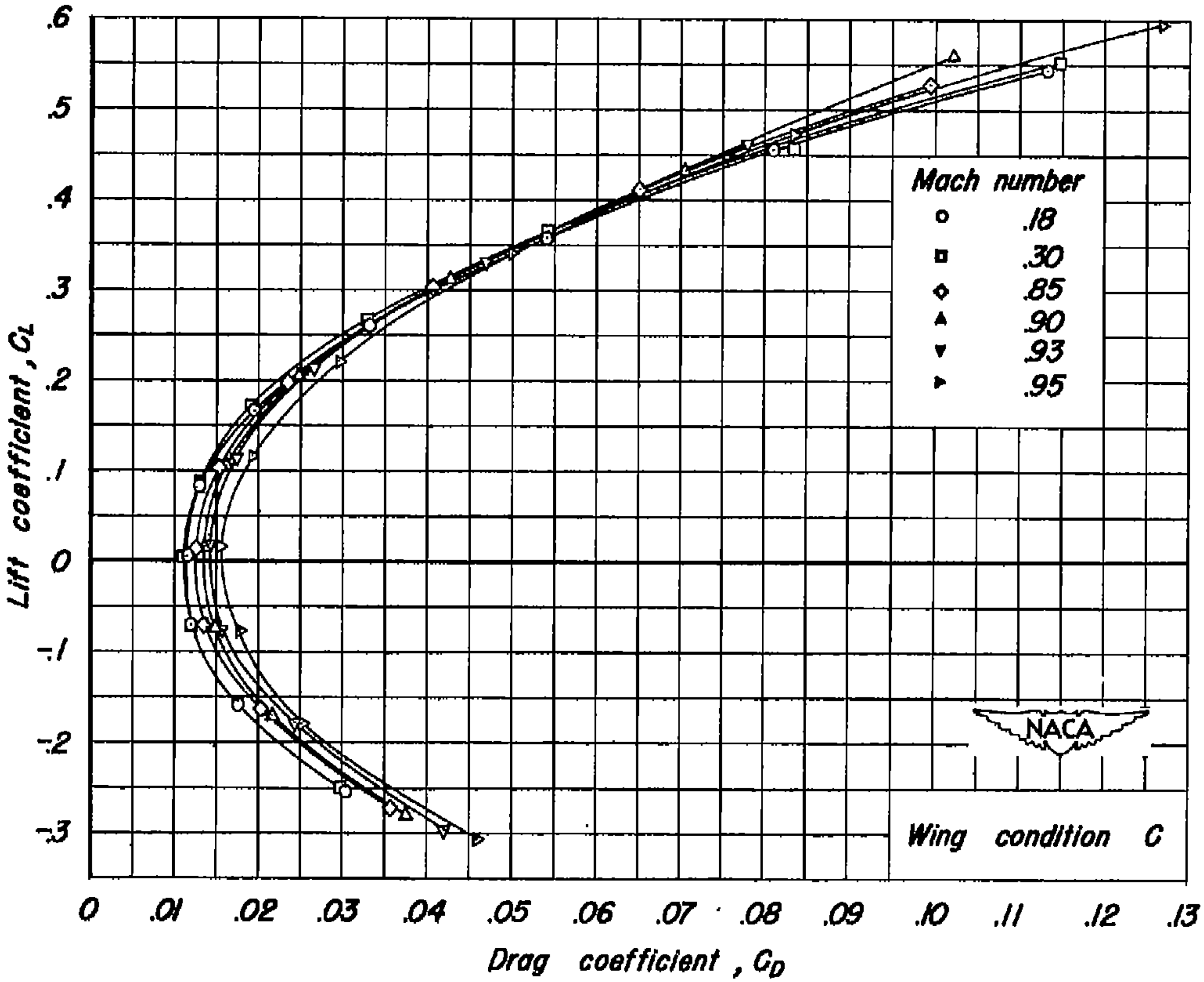
(a) C_L vs α

Figure 13.–The effect of Mach number on the aerodynamic characteristics of a triangular wing with fuselage at a Reynolds number of 5,300,000.



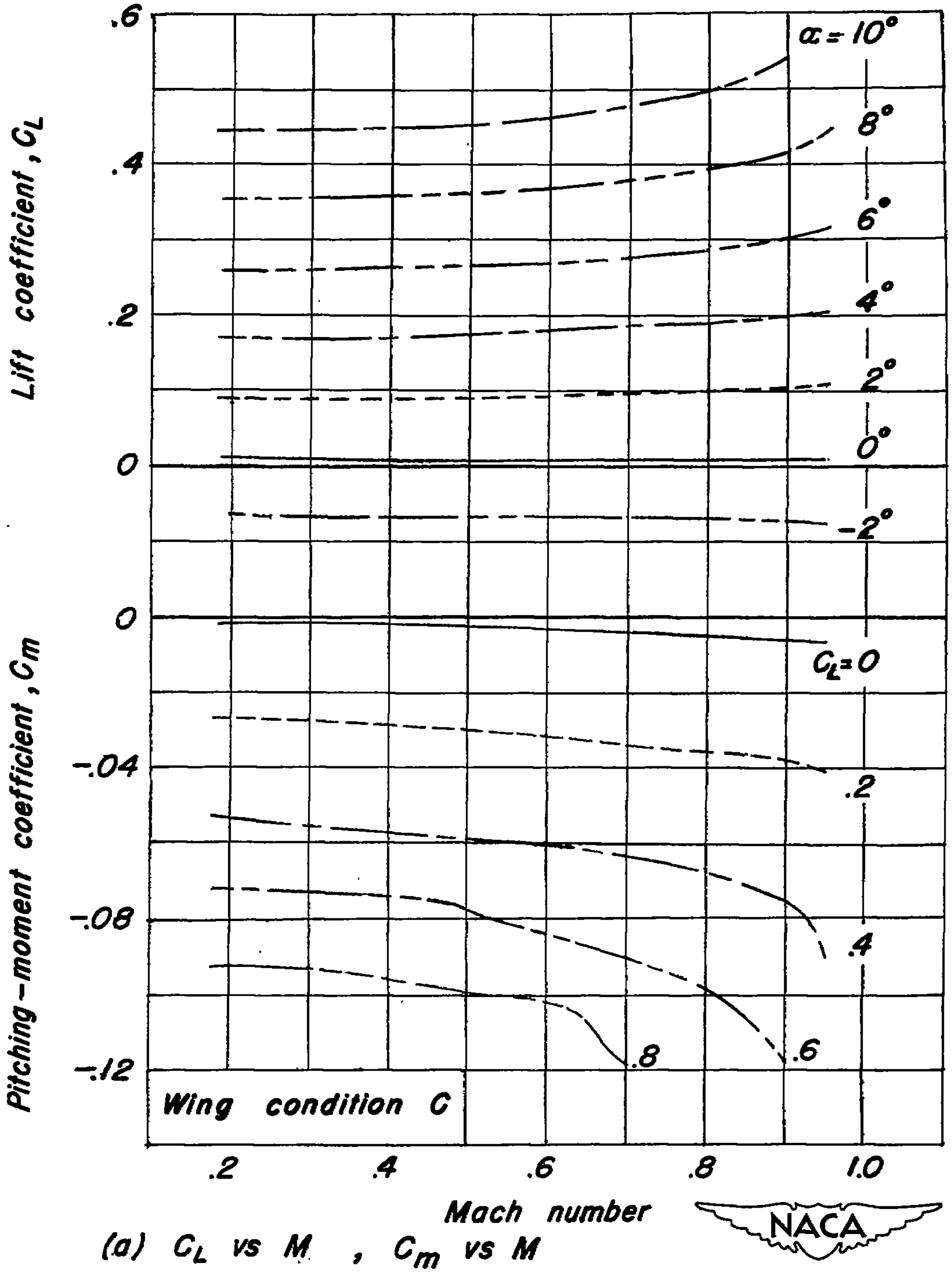
(b) C_L vs C_m

Figure 13.- Continued.



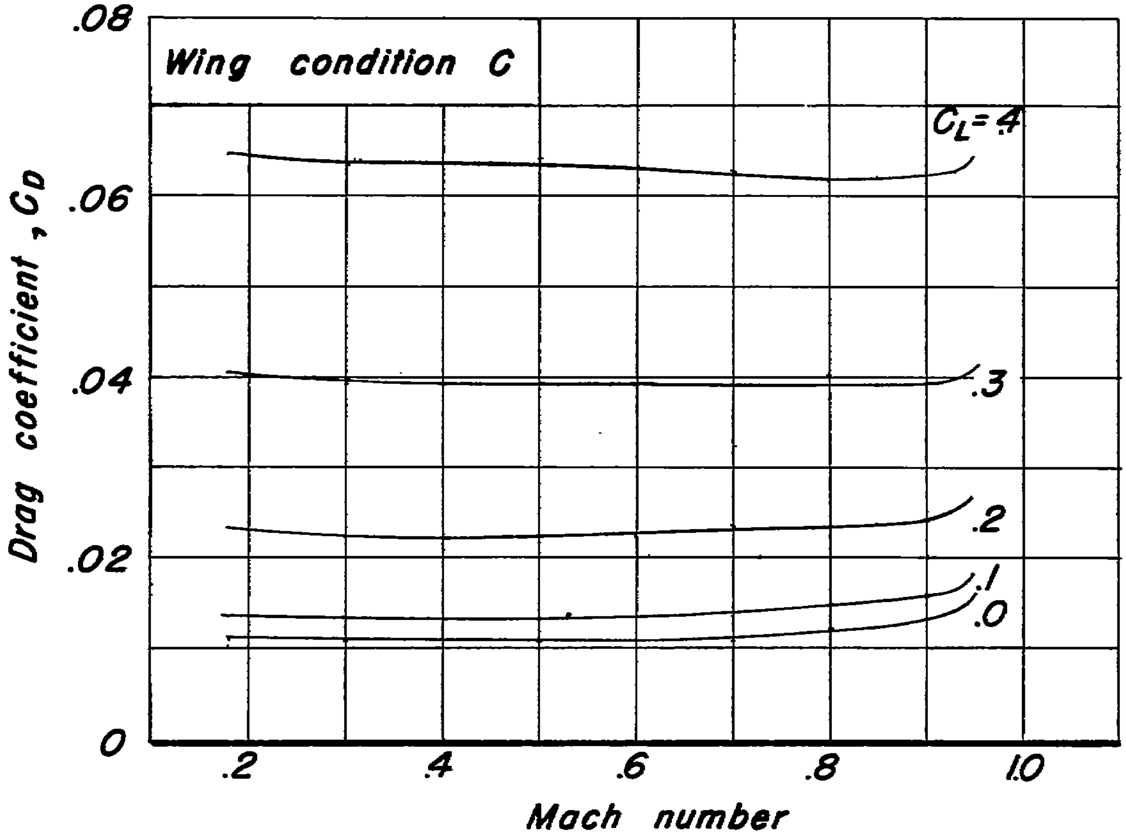
(c) C_L vs C_D

Figure 13.– Concluded.



(a) C_L vs M, C_m vs M

Figure 14.– The effect of Mach number on the lift, drag, and pitching-moment coefficients of a triangular wing with fuselage at a Reynolds number of 5,300,000.



(b) C_D vs M

Figure 14.–Concluded.

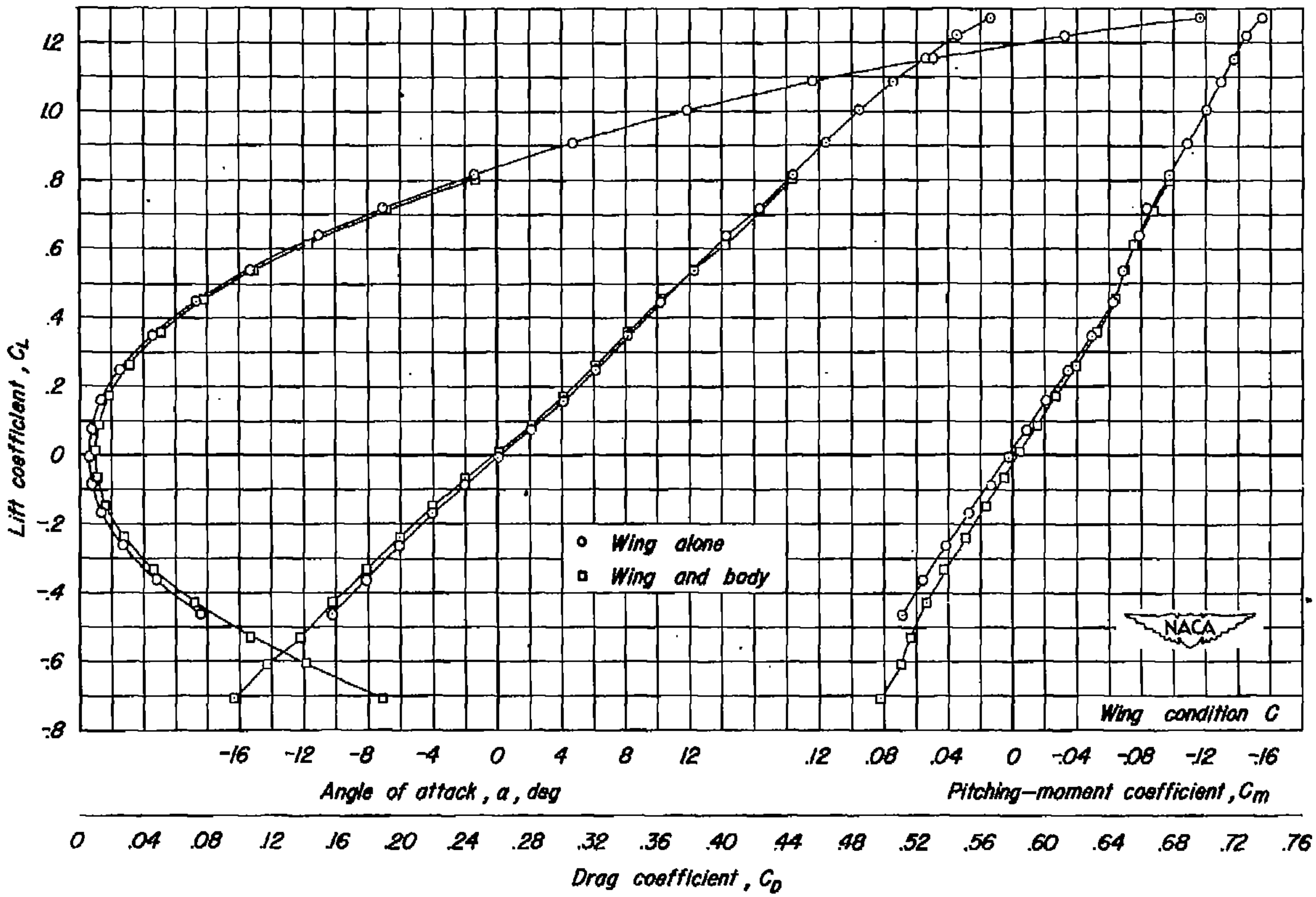


Figure 15.-The effect of the fuselage on the aerodynamic characteristics of a triangular wing at a Mach number of 0.18 and a Reynolds number of 15,000,000.

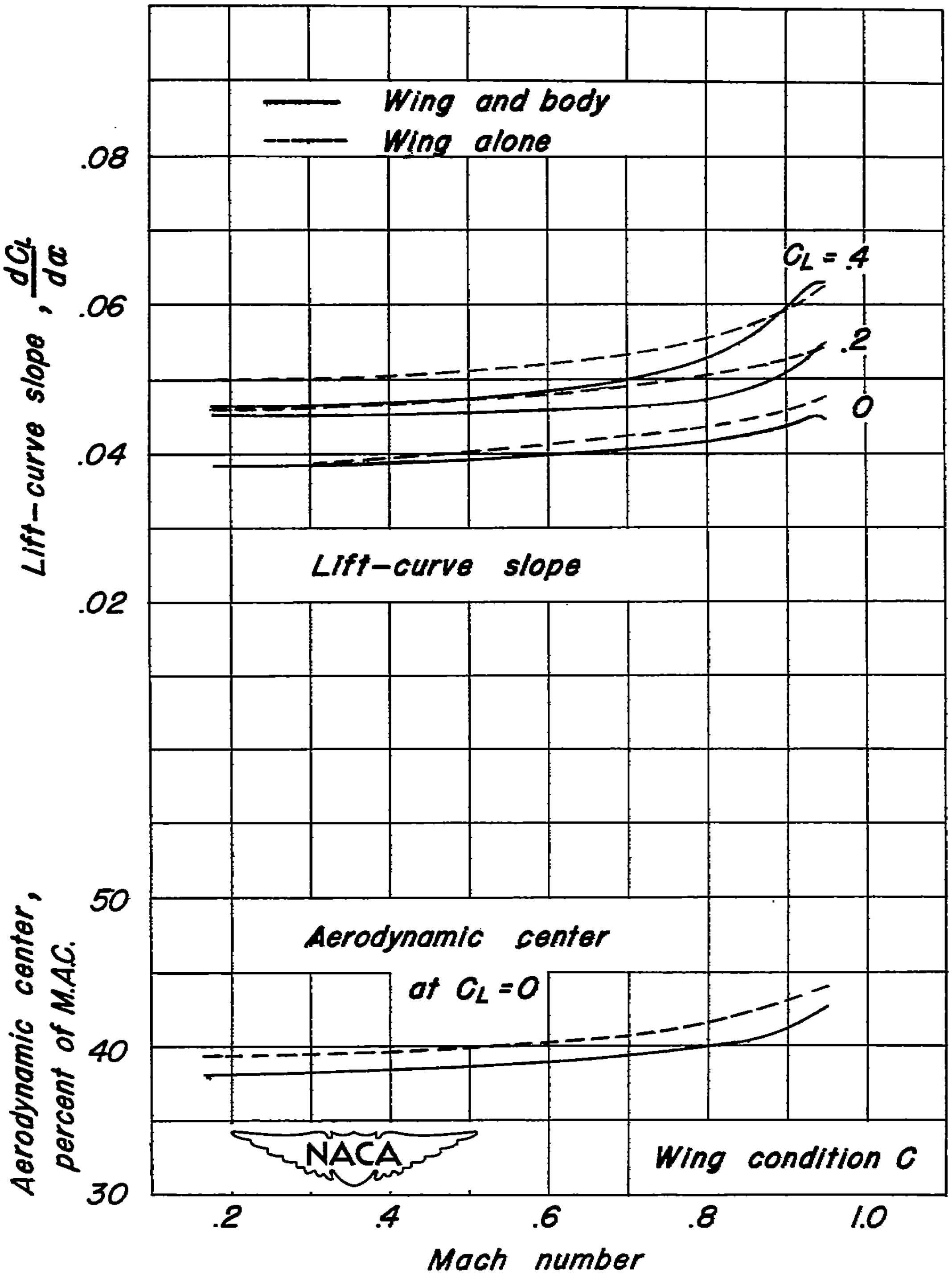


Figure 16.—The effect of Mach number on lift-curve slope and aerodynamic center of a triangular wing with fuselage at a Reynolds number of 5,300,000.

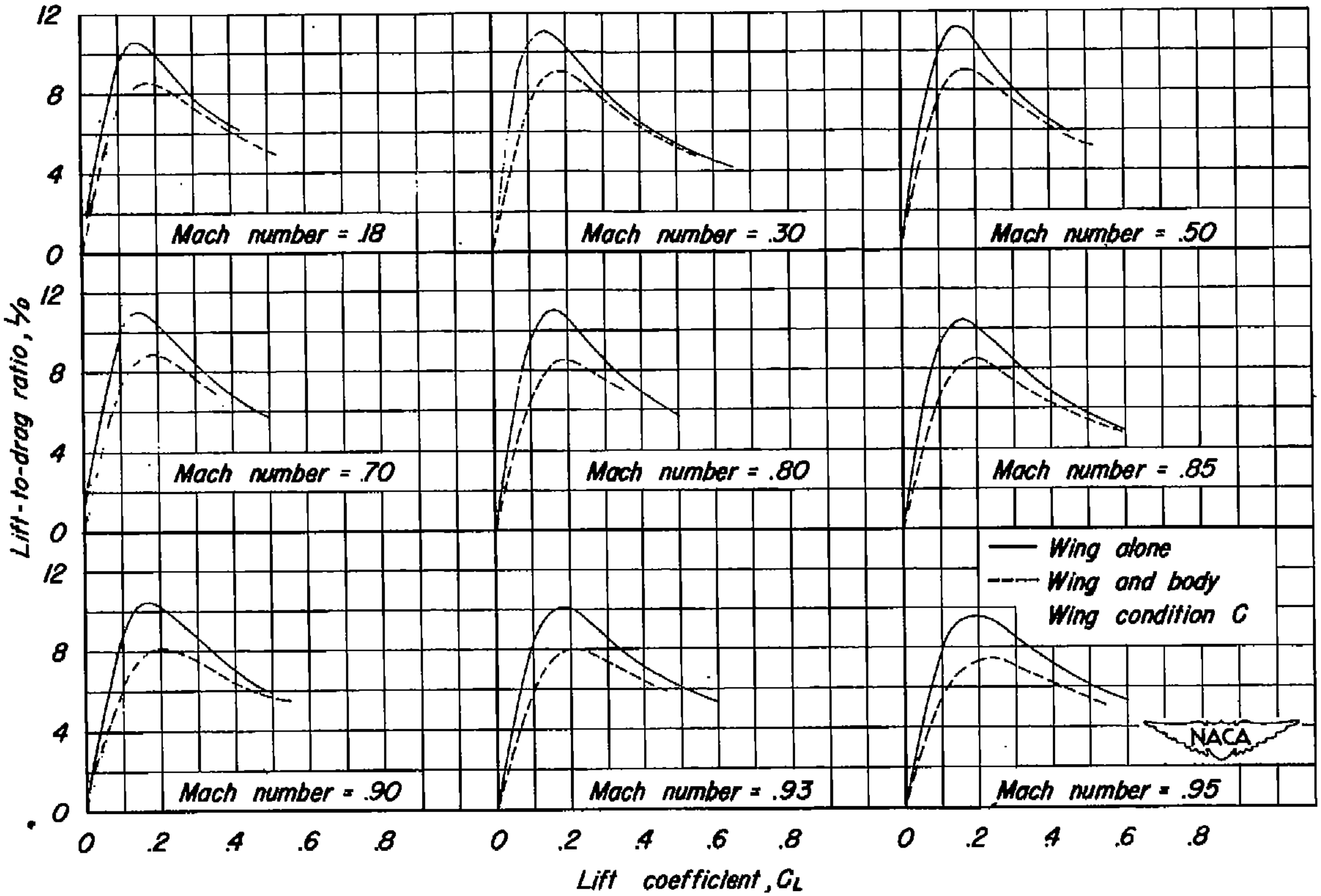
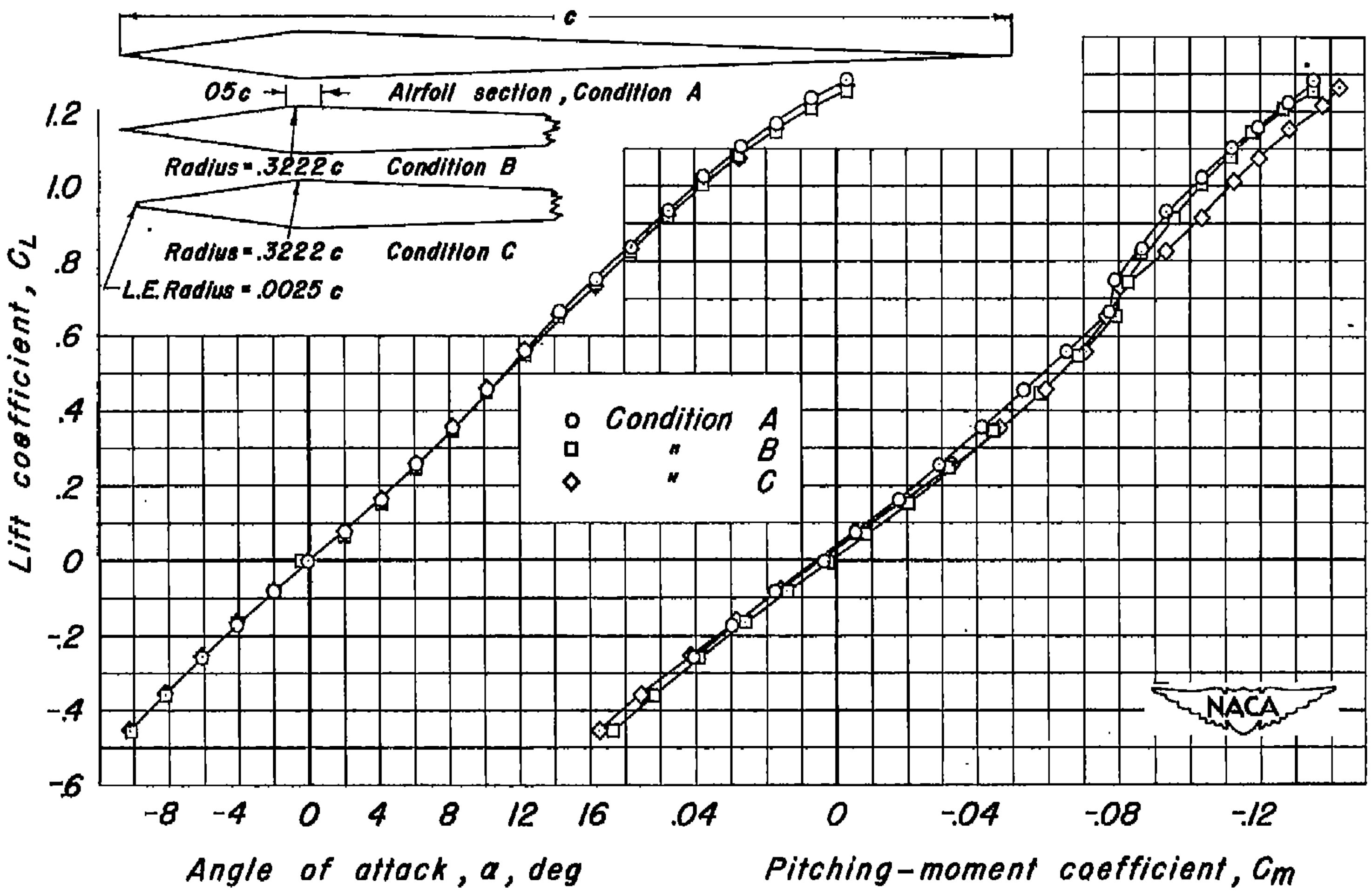
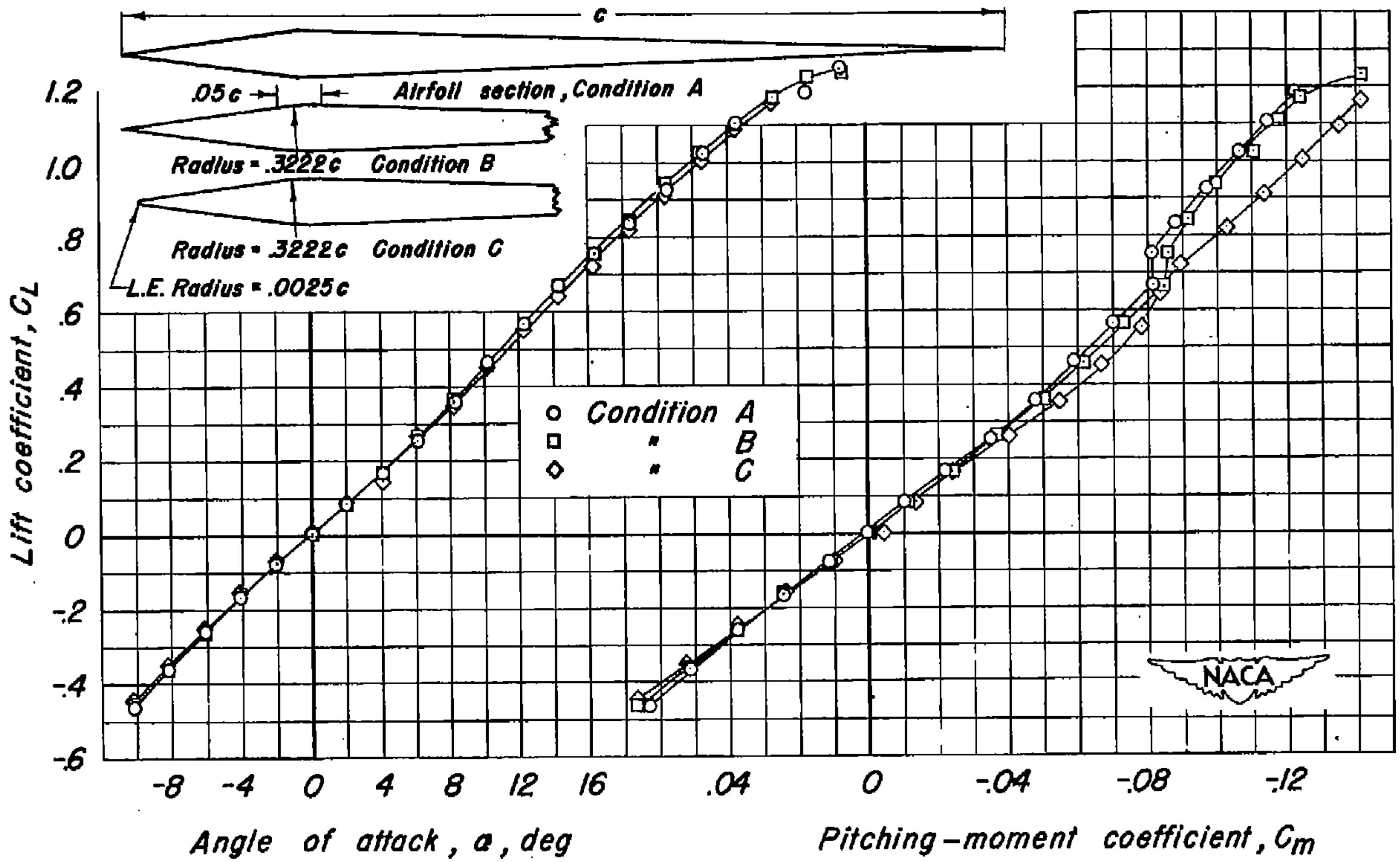


Figure 17.- The effect of the fuselage on the variation of lift-drag ratio with lift coefficient for a triangular wing at several Mach numbers and a Reynolds number of 5,300,000.



(a) Reynolds number, 5,000,000

Figure 18.- The effect of minor modifications to the wing profile on the aerodynamic characteristics of a triangular wing at a Mach number of 0.18.



(b) Reynolds number, 27,500,000

Figure 18.- Concluded.

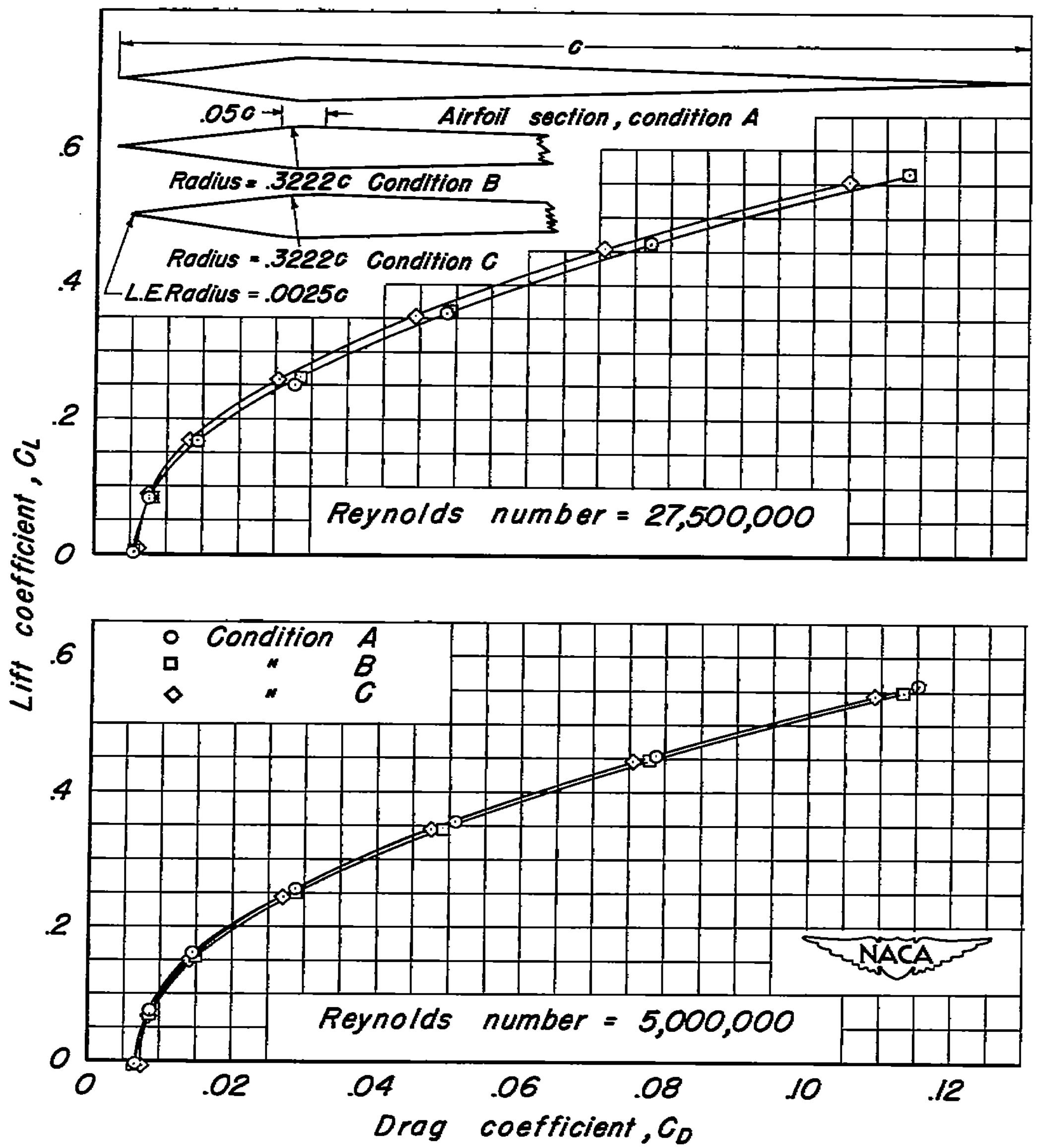
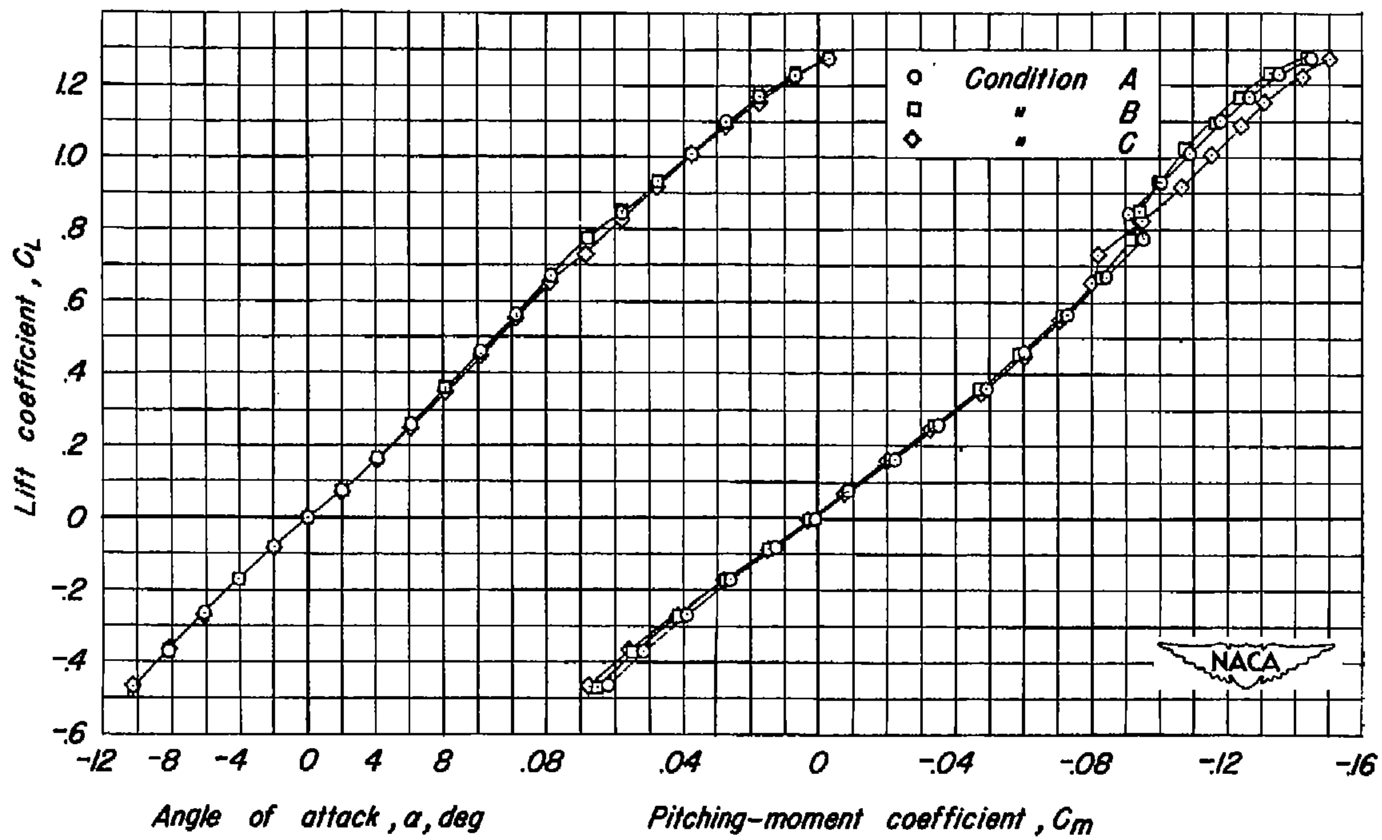
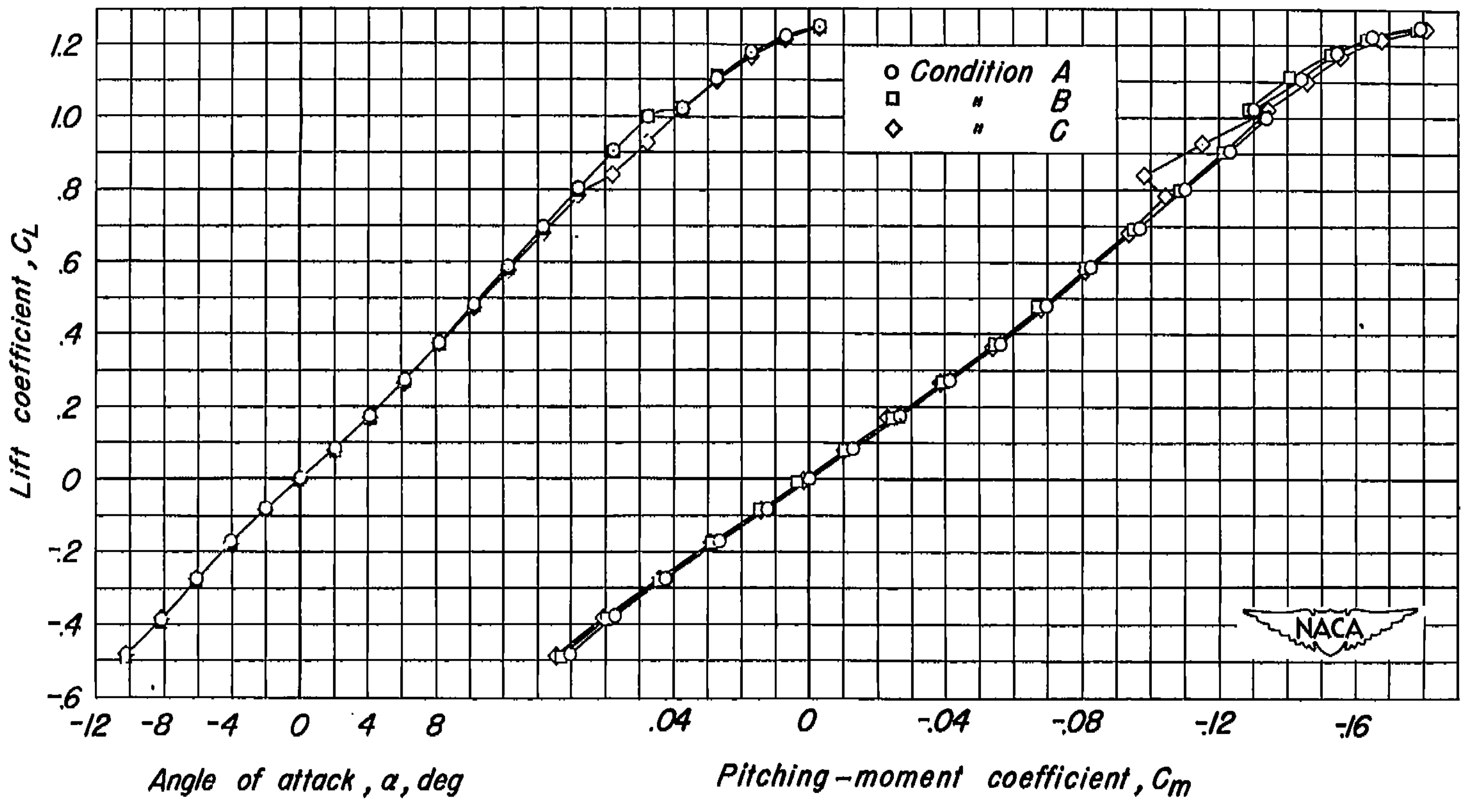


Figure 19.- The effect of minor modifications to the wing profile on the drag characteristics of a triangular wing at a Mach number of 0.18.



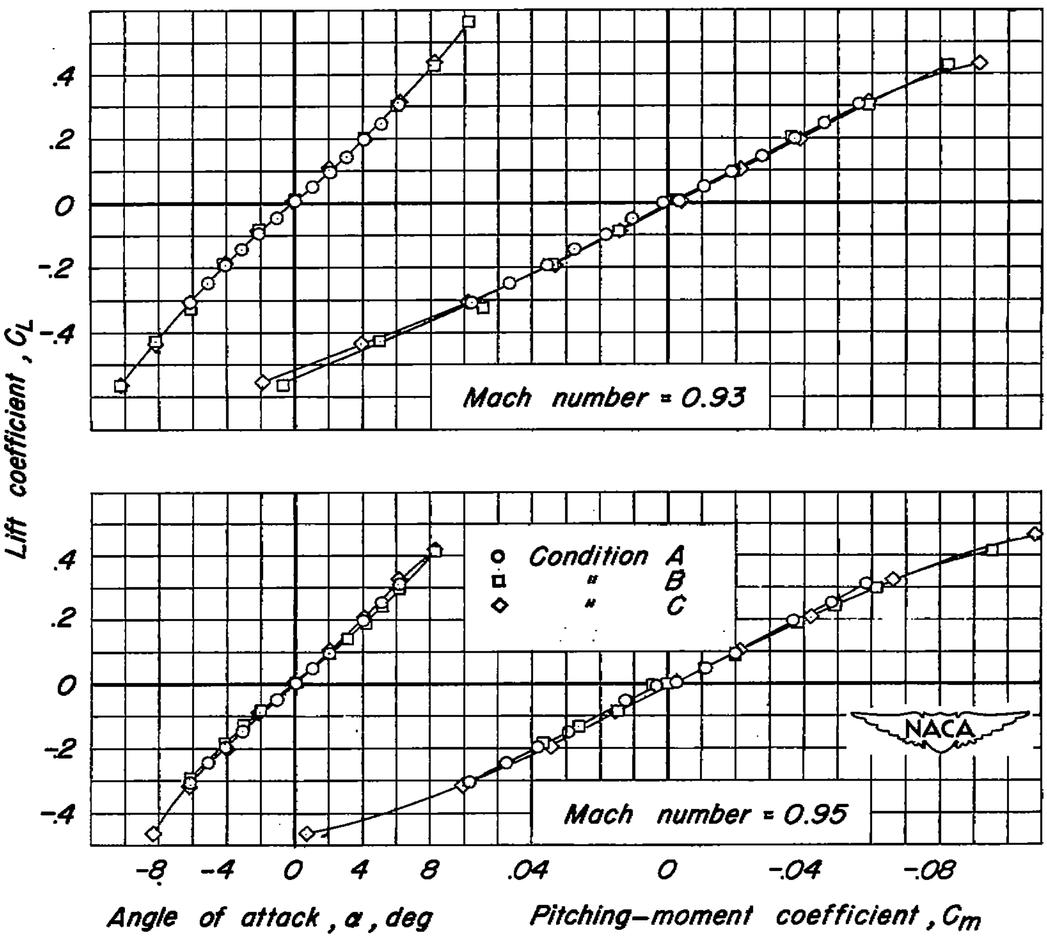
(a) Mach number, 0.3

Figure 20.- The effect of minor modifications to the wing profile on the aerodynamic characteristics of a triangular wing at a Reynolds number of 5,300,000.



(b) Mach number, 0.6

Figure 20.- Continued.



(c) Mach number, 0.93, 0.95

Figure 20.—Concluded.